DOCUMENT RESUME

ED 331 881 TM 016 437

AUTHOR	Vaughan, Willard S., Jr., Ed.
TITLE	Cognitive and Neural Sciences Division 1990 Programs.
INSTITUTION	Office of Naval Research, Arlington, VA. Cognitive and Neural Sciences Div.
REPORT NO	OCNR-114290-17
PUB DATE	Aug 90
NOTE	230p.
PUB TYPE	Reference Materials - General (130) -- Reports - Evaluative/Feasibility (142)
EDRS PRICE	MF01/PC10 Plus Postage.
DESCRIPTORS	Abstracts; *Biological Sciences; *Cognitive Psychology; *Federal Programs; Intelligence; *Neuropsychology; Perception; *Program Descriptions; Research and Development; *Research Projects; Research Reports
IDENTIFIERS	*Office of Naval Research

ABSTRACT

Research and development efforts carried out under sponsorship of the Cognitive and Neural Sciences Division of the Office of Naval Research during fiscal year 1990 are described in this compilation of project description summaries. The Division's research is organized in three types of programs: (1) Cognitive Science (the human learner--cognitive architectures and abilities; knowledge, skill, and expertise; learning and instruction; and model-based measurement); (2) Perceptual Science (vision and visual attention; audition; haptics and sensory guided motor control; and human factors technology); and (3) Biological Intelligence (computation in large neural networks; chemical modulators of information processing; neural processing of sensory information; local neural circuit interactions; and behavioral immunology). Two other types of programs are included: manpower, personnel, and training research and development programs; and university research initiatives--decision making in hierarchical teams. Each program is described by an overview followed by thematic clusters of related efforts. Each cluster is followed by individual projects active in 1990. The title, principal investigator, project code, contract number, current end date, objective, approach, and progress are provided for 194 projects, representing 101 contractors. Indexes are provided to contractors, projects, and principal investigators. (SLD)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

U.S. DEPARTMENT OF EDUCATION
Office of Educational Research and Improvement
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

☑ This document has been reproduced as received from the person or organization originating it

☐ Minor changes have been made to improve reproduction quality

- Points of view or opinions stated in this document do not necessarily represent official OERI position or policy

BEST COPY AVAILABLE

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503

1. AGENCY USE ONLY *(Leave blank)*	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	Aug 90	Summary 10/1/89 to 9/30/90

4. TITLE AND SUBTITLE
Cognitive and Neural Sciences Division 1990 Programs

5. FUNDING NUMBERS
PE 61153N

6. AUTHOR(S)
Edited by Willard S. Vaughan

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Office of Naval Research
Cognitive and Neural Sciences Division
Code 1142
Arlington, VA 22217-5000

8. PERFORMING ORGANIZATION REPORT NUMBER
OCNR 114290-17

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES
This is a compilation of abstracts representing R&D sponsored by the ONR Cognitive and Neural Sciences Division.

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release;
Distibution unlimited

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

This report documents R&D performed by Principal Investigators under the sponsorship of the ONR Cognitive and Neural Sciences Division during fiscal year 1990.

14. SUBJECT TERMS
neural networks neural plasticity perception
cognition learning and memory knowledge acquisition
motor control sensory information processing

15. NUMBER OF PAGES
257

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED	SAR

NSN 7540-01-280-5500

Standard Form 298 (Rev 2-89)
Prescribed by ANSI Std Z39-18
298-102

FOREWORD

This booklet describes research carried out under sponsorship of the Cognitive and Neural Sciences Division of the Office of Naval Research (ONR) during fiscal year 1990. The Division's research is organized in three programs: Cognitive Science, Perceptual Science and Biological Intelligence. Each program is described by an overview which is followed by thematic clusters of related efforts. Each cluster is described by individual projects which were active during 1990.

This is one of several means by which we communicate and coordinate our efforts with other members of the research-sponsoring and research-performing communities. We encourage your comments about any feature of this booklet or about the programs themselves. If you wish further information, please do not hesitate to contact members of the staff listed in the Introduction. We welcome your interest in our programs and hope that you will continue to keep us informed of related research efforts.

W. S. VAUGHAN, JR.

CONTENTS

FOREWORD i

INTRODUCTION v

COGNITIVE SCIENCE

The Human Learner: Cognitive Architectures and Abilities 1
Knowledge, Skill and Expertise 13
Learning and Instruction 21
Model-based Measurement 39

PERCEPTUAL SCIENCE

Vision and Visual Attention 59
Audition 87
Haptics and Sensory Guided Motor Control 99
Human Factors Technology 113

BIOLOGICAL INTELLIGENCE

Computation in Large Neural Networks 127
Chemical Modulators of Information Processing 155
Neural Processing of Sensory Information 165
Local Neural Circuit Interactions 187
Behavioral Immunology 207

MANPOWER, PERSONNEL AND TRAINING RESEARCH AND DEVELOPMENT PROGRAM 219

UNIVERSITY RESEARCH INITIATIVE: DECISION MAKING IN HIERARCHICAL TEAMS 227

INDEX

Contractors 235
Principal Investigators 237
R&T Project Codes 239

INTRODUCTION

Cognitive and Neural Sciences Division programs are carried out under contracts and grants awarded on the basis of proposals received in response to a Broad Agency Announcement in the Commerce Business Daily. They are evaluated on the scientific merit of the proposed research, the facilities available for its conduct, the competence of the principal investigators, and relevance to Navy needs. The elements that shape our research program are scientific gaps and opportunities, and operational needs identified in Navy planning documents. Our overall aim is to support quality science for the good of the Navy and the nation.

Cognitive and Neural Sciences programs develop fundamental knowledge about human capabilities and performance characteristics which guide Navy and Marine Corps efforts to improve personnel assessments for selection and classification, training, equipment and system designs for human operation and maintenance. One goal is to provide scientific underpinning for more accurate prediction and enhancement of human performance in training and operational environments. A second goal is to understand the neurobiological constraints and computational capabilities of neural information processing systems for future device implementation. The Division has core programs in cognitive, perceptual and neural sciences which seek to understand human behavior at successively deeper levels of analysis. In addition, several Accelerated Research Initiatives (ARI) are underway which complement and extend research topics of interest to the core programs.

Most of the programs are basic in nature, with a selected augmentation of exploratory development effort. This mix of basic and applied research is developed and managed by the Division staff with the able assistance of the other ONR scientists and with helpful guidance and advice from representatives of various Navy and Marine Corps activities. The programs seek to involve innovative civilian scientists in areas of research relevant to Navy and Marine Corps interests, and by so doing provide new perspectives, new insights, and new approaches to naval manpower, personnel, training, equipment and system design problems. This arrangement provides channels for information to flow back and forth between the civilian research community and the naval community, each keeping the other abreast of new developments. The emphasis is on the creation and exploitation of a cumulative scientific knowledge base upon which new technologies can be developed to improve effectiveness of Navy and Marine Corps men and women.

Continuous efforts are made to coordinate the Division's research program with other ONR Divisions, with in-house Navy Laboratories and Centers, and with the research sponsored by other services and other agencies. We work closely with Technology Area Managers in the Office of Naval Technology (ONT), and with their Block Managers in Navy Laboratories and Centers to facilitate transitions from basic to applied research.

The Cognitive and Neural Sciences Division is part of the Life Sciences Directorate, which also includes the Biological Sciences Division. Dr. Steven F. Zornetzer is Director of the Life Sciences Directorate, and Commander Charles J. Schlagel is the Deputy Director for Life Sciences.

DIVISION STAFF

The members of the staff of the Cognitive and Neural Sciences Division are listed below:

DR. W. S. VAUGHAN, JR., DIVISION DIRECTOR
Telephone: (202) 696-4505

Cognitive Science Research Programs

Dr. Susan E. Chipman, Program Manager
Dr. Charles E. Davis
Telephone: (202) 696-4318

Perceptual Science Research Programs

Dr. Harold L. Hawkins, Program Manager
Dr. John J. O'Hare *
Dr. Teresa A. McMullen
Mr. Gerald S. Malecki
Telephone: (202) 696-4323

Biological Intelligence Research Programs

Dr. Joel L. Davis, Program Manager
Dr. Donald P. Woodward
Dr. Thomas M. McKenna
Telephone: (202) 696-4744

* Retired during 1990.

COGNITIVE SCIENCE

The Cognitive Science research program of the Office of Naval Research aims to provide a theoretical understanding of the human learner and performer in the domain of complex cognitive skills. This general goal unfolds into several interrelated more specific objectives. First, to provide a theory of the fundamental characteristics of the learner and performer as an information processing system, including a theory of the basis of individual differences in cognitive abilities. Second, to provide a theory of the nature of acquired knowledge and skill involved in performing complex problem-solving and decision-making tasks. Third, to provide a cognitive learning theory that can account for the way in which such complex, structured bodies of knowledge and skill are acquired. Fourth, to provide a precise theory of instruction, founded on cognitive theory, to be used to guide effective education and training of complex cognitive skills such as those involved in performing Naval duties. Finally, this research program aims to provide theoretical foundations for personnel testing and assessment. Research in Cognitive Science is expected to lead to the design of efficient instructional systems across a range of content domains of interest to Navy and Marine Corps training programs, to the development of efficient and accurate computer-based personnel assessment systems, and to the design of expert advisory systems compatible with human intellectual characteristics.

The Human Learner: Cognitive Architectures and Abilities

Research aimed at discovering and characterizing the stable features of the human learner emphasizes later stages of information processing--cognition rather than perception. This cluster of projects is developing theories for the functional architecture of cognition, including subtheories for memory and elemental cognitive processing operations. Current priorities emphasize the use of neural evidence to constrain theories of cognitive architecture. Results of research in this cluster will provide sound theoretical bases for personnel testing and selection, and for the individualization of instructional treatments based on accurate diagnosis of cognitive capacities.

Knowledge, Skill and Expertise

Research on knowledge and expertise aims at formal theories of complex human skill. The program emphasizes the expression of theories in the formal languages provided by mathematics and computer science and includes empirical tests of developed models. Projects target a wide range of complex skills, emphasizing problem-solving and decision-making, so that a general theory can evolve. Research results are intended to provide a general model for skill analysis that can be used to design appropriate training or expert advisory systems.

Learning and Instruction

Research on Learning and Instruction aims to produce a knowledge-rich theory of learning that integrates results of work in the prior clusters and develops a coordinated instructional theory that explains how to produce change -- learning -- in desired directions. Under the Knowledge Acquisition ARI, there is currently a major emphasis on AI-based models of complex human learning. Artificially intelligent, computer-assisted instructional systems as well as more conventional instructional settings are the application areas for the program. In addition, projects are supported which involve either fundamental advances in AI bases for intelligent tutoring or the use of intelligent tutoring systems as a laboratory for investigation into general issues of learning and instruction.

Model-based Measurement

Research in this cluster is developing a technology for constructing verifiable empirically-based models of eminent aspects of performance which lead to robust item-level predictions on complex cognitive tasks. For domains for which cognitive science provides detailed qualitative explanations of performance in terms of well-defined mental structures and processes, research is developing a technology for linking task performance to a taxonomy of those structures and processes. This research provides the technology base for improvements to the testing components which constitute the heart of Navy and Marine Corps personnel and training systems in which case-by-case decisions are made. This includes systems for personnel selection and classification, for career counselling, for the design/selection of instructional interventions, for performance aiding, for certification and for performance evaluation. As the Navy modernizes those systems to take advantage of potential improvements in a computer-based workplace, this research is providing the wherewithal for fundamental improvements to those systems through fundamental improvements to their measurement components.

PERCEPTUAL SCIENCE

Research in the Perceptual Science program emphasizes issues of perceptual primitives and their representations and transformations in the domains of vision, audition, touch and manipulation, multimodal integration, and the control of motor activity. Research results are expected to transition to Navy and Marine Corps systems in the form of enhanced technologies for human factors engineering, machine vision, acoustic signal classification, adaptive filtering, and dexterous manipulators for autonomous and teleoperated vehicles.

Vision and Visual Attention

Vision is viewed as a computational process and projects in this cluster emphasize interdisciplinary approaches. Mathematical models are constrained by neurophysiological evidence and tested by psychophysical experiments. Focus is on modeling early, intermediate, and late-visual processes that construct and recognize visual forms and integrate these forms into complex visual representations. A second thrust inquires into the nature of neural mechanisms of control. In their more evolved forms, visual systems contain special modulatory mechanisms that enable them to adjust quickly and adaptively to momentary fluctuations in environmental demand. These are the neural control mechanisms underlying attention and arousal. Interest within this cluster is on empirical research in human visual performance, neuroanatomy, neurophysiology, and neuropsychology aimed at investigation of the control structures and circuitries underlying visual attention, and the neurochemical modulators governing attentional processing.

Audition

In audition, research projects examine the processing of steady state, transient, and reflected acoustic signals, and model the concurrent processing of complex sound properties and interactions. Current emphasis is on understanding and modeling the classification processes of human listeners, augmented by neurophysiological evidence from other biological species with interesting auditory capabilities and the signal processing capabilities of artificial neural nets.

Haptics and Sensory Guided Motor Control

Sensory guided motor control is a new area of interest in Perceptual Science. Emphasis is on experimental and theoretical studies of the fundamental issues of coordinated motor function, including the computational bases of force control, and the timing and sequencing of action. Special emphasis is given to work investigating the processes through which sensory information functions as an adaptive guide to coordinated action. Interdisciplinary research is encouraged in psychology, neuroscience, and computer science to achieve an understanding of sensory guided motor control that will contribute toward enhancement of action adaptability within robotic systems.

The processing of tactile and kinesthetic information in object recognition is a related area of interest in this cluster. Priority research issues include the identification of perceptual primitives, neural network models for tactile processing in somatosensory centers, and perceptual mechanisms that mediate inferential judgments about object properties, classifications and function. Interdisciplinary research is encouraged in psychology, neurophysiology and computer science with the goal of understanding the haptic system in order to provide future robotic devices with intelligent hands.

Human Factors Technology

The work described in this cluster constitutes an Exploratory Development project which is designed to extend the basic research program in Perceptual Science toward applications in Naval systems. Currently the project consists of applied research in three topic areas: decision making in command and control systems; teleoperated and robotic systems; and acoustic signal analysis. Current work in the command and control area investigates information processing and decision-making in Naval mission planning, airborne ASW, and sonar signal analysis. Work in teleoperation and robotics seeks to develop the conceptual and technical bases for extending human-like sentience and dexterity into previously unattainable and hazardous underwater environments. Work on acoustic signal analysis aims to develop improved techniques for the detection, localization, and classification of active and passive sonar signals.

BIOLOGICAL INTELLIGENCE

Biological Intelligence programs foster research to elucidate the organization, structural bases, and operational algorithms characterizing information processing networks within neural systems. The goal is to uncover neural architectures and algorithms that can profitably be emulated technologically to yield artificial information processing capabilities of kinds now unique to biological systems. These neural architectures may be derived from either sensory-, motoric- or cognitively-related structures. Overall, the program of research seeks to uncover the organizational principles and operational rules exploited within neural networks to compute intelligent functions, and to emulate these network characteristics within electronic information processing systems.

Computation in Large Neural Networks

This research examines the global dynamics of biological neural networks composed of large numbers of neurons. The goal of this research is a formal description and simulation of the biological computations underlying information processing, learning and cognition in order to design electronic information processing systems with these network characteristics.

Chemical Modulators of Information Processing

This cluster of research explores the mechanisms by which neurochemical modulators and neurotransmitters enable neural plasticity, modify information processing, and alter network dynamics.

Neural Processing of Sensory Information

This research is concerned with the functional organization of sensory neocortex, the computations performed in sensory cortical networks, and the adaptive plasticity of these networks evident at the level of the neuronal receptive fields. Sensory processing is studied in vision, audition, olfaction, touch and motor control.

Local Neural Circuit Interaction

This research advances our understanding of the elements of neural circuits, the individual neurons, by investigating neuronal biophysics and small ensembles of neurons. This research encompasses investigations of the integrative capacities of the dendritic branching structure of neurons, the rules which govern modification of synaptic strength, and the role of membrane electrical properties in information processing and neural plasticity.

Behavioral Immunology

This program is an Accelerated Research Initiative jointly funded by the Biological Sciences and the Cognitive and Neural Sciences Divisions. The program aims at understanding the processes, both biological and psychological, by which life stresses come to influence the functions of the immune system and susceptibility to illness. The projects described are those currently managed by this Division.

MANPOWER, PERSONNEL AND TRAINING RESEARCH AND DEVELOPMENT PROGRAM

This is an interdisciplinary program of exploratory development managed by Dr. Stanley Collyer in the OCNR Office of Naval Technology. Scientific Officers for these projects are located in the Cognitive and Neural Sciences Division and in the Mathematics Division of the Office of Naval Research. Projects which are closely related to the primary emphases of the Cognitive and Neural Sciences Division have been grouped with the related basic research projects, identified by the notation that funds have been provided by ONT Code 222. In this section, there are descriptions of projects addressing unique priorities of the MPT program. This report includes descriptions only for those contracts managed by a Scientific Officer in the Cognitive and Neural Sciences Division.

This program is closely coupled with the operating arms of the Navy and Marine Corps through the mechanism of a planning committee, whose members include ONR Scientific Officers, the Naval Civilian Personnel Command, the Naval Military Personnel Command, the Navy Recruiting Command, the Navy Personnel Research and Development Center, several directorates in the Office of the Chief of Naval Operations, and the Navy Secretariat.

UNIVERSITY RESEARCH INITIATIVE: DECISION MAKING IN HIERARCHICAL TEAMS

This is a special program of basic research developed under the Department of Defense Research Initiation Program within the University Research Initiative. Emphasis is on theory development, variable definition and measurement approaches, modeling and experimentation to deepen our understanding of how coordination is achieved and maintained by hierarchical decision-making teams in stressful environments. This section characterizes the six awards made in FY90 to explore issues in hierarchical team decision making.

A parallel program of exploratory development research was begun by ONT Code 222 during FY90, Tactical Decision Making Under Stress (TADMUS). Mechanisms to insure close coordination between these two programs have been put in place to strengthen transition opportunities.

COGNITIVE SCIENCE

THE HUMAN LEARNER: COGNITIVE ARCHITECTURES AND ABILITIES

TITLE: Learning and Individual Differences: An Ability/Information-Processing Framework for Skill Acquisition

PRINCIPAL INVESTIGATOR: Phillip L. Ackerman
University of Minnesota
Department of Psychology
(612) 625-9812

R&T PROJECT CODE: 4422543

CONTRACT NO: N0001489J1974

CURRENT END DATE: 31 JUL 1992

Objective:
The objective is to investigate the relationship between measures of various psychometric abilities and the course of acquisition of skills of various types: perceptual-motor skills, cognitive skills with minimal perceptual-motor components, and fine motor coordination skills.

Approach:
Nine experiments are planned, using appropriately selected skill learning tasks, to examine such questions as the role of cognitive abilities in determining skill transfer, the possibility of changes in measured abilities as a consequence of practice in a skill and the role of various psychometric abilities in determining asymptotic performance. A wide variety of psychometric ability measures will be taken and subjects will undergo prolonged training in order to develop high, asymptotic levels of skill. Tasks studied include variants of a simulated air-traffic control task.

Progress:
A theory of the relation between different classes of traditional psychometric ability measures and individual differences in performance during successive phases of skill acquisition has been tested. The ability-performance relations have now been shown to generalize from the simple experimental tasks originally used to a more complex simulated air-traffic control task. The effectiveness of different training regimes for individuals of different ability profiles has also been explored.

Report:
Ackerman (1988) Determinants of individual differences during skill acquisition: Cognitive abilities and information processing. JEP: General, 117, 288-318.
Ackerman (in press) Individual differences theory in industrial and organizational psychology. In: M.D. Dunnette (Ed) Handbook of industrial and organizational psychology.

TITLE: Use of Rational Analysis to Design an Architecture for Learning and Problem Solving

PRINCIPAL INVESTIGATOR: John R. Anderson
Carnegie-Mellon University
Department of Psychology
(412) 268-2788

R&T PROJECT CODE: 4422559

CONTRACT NO: N0001490J1489

CURRENT END DATE: 31 DEC 1992

Objective:
The primary purpose of this grant is to undertake a revision of the ACT* theory of human cognitive architecture, taking into account the implications of a rational analysis of the environmental requirements on human cognition that the PI has already conducted. Empirical studies of problem solving will also be conducted to provide additional constraints on the theory.

Approach:
The lessons arising from a rational analysis of the requirements of a number of theoretically important cognitive tasks will be reflected in a new and improved formulation of the ACT class of computational theories of human cognition. In addition, new empirical problem solving studies will be conducted in order to provide guidance to how the theory should treat learning in situations in which rules are probabilistic in character, not explicitly taught but induced without instruction, and which involve explicit management of costs and gains.

Report:
Anderson, J. R. (1990) The Adaptive Character of Thought. Hillsdale, NJ: Erlbaum
Anderson, J. R. (1990) A rational analysis of categorization. In the Proceedings of the Seventh International Conference on Machine Learning. 76-84.

TITLE: Functional Architecture of Visual Object Recognition: Cognitive Neuropsychological Studies

PRINCIPAL INVESTIGATOR: Martha Farah
Carnegie-Mellon University
Department of Psychology
(412) 268-2789

R&T PROJECT CODE: 4422553

CONTRACT NO: N0001489J3016

CURRENT END DATE: 14 NOV 1990

Objective:
The objective of this grant is to gain an improved understanding of processes that enable us to recognize objects by sight--i.e., to advance scientific knowledge of the functional architecture of visual object recognition.

Approach:
The research will combine theories and methods of cognitive psychology with those of neuropsychology, focussing upon four well-known dissociations and their implications for the functional architecture of normal visual object recognition. In particular, the following dissociations will be examined: recognition vs. localization of visual stimuli, conventional vs. unconventional viewing perspectives, animate vs. inanimate objects, and orthographic vs. nonorthographic objects.

Progress:
A study of two agnosic patients has produced evidence for material-specificity in object recognition (in particular, a selective impairment for animate v.s. inanimate objects). The PI also has completed a book on the neuropsychology of visual object recognition.

Report:
M. Farah (1990) Disorders of object recognition and what they tell us about normal vision. MIT Press.

TITLE: Brainprints: Computer-Generated Maps of the Human Cerebral Cortex in Vivo

PRINCIPAL INVESTIGATOR: Michael S. Gazzaniga
Dartmouth College
Department of Psychology
(603) 646-2741

R&T PROJECT CODE: 4422557

CONTRACT NO: N0001489J3035

CURRENT END DATE: 30 JUN 1991

Objective:

The purpose of the work is to further develop computational methodology for converting NMR scan data about human brain damage into a functionally significant mapping onto the computationally "unfolded" surface of the cerebral hemisphere for the purpose of more precisely specifying the relationships between physical damage to the brain and functional consequences for cognitive capacities.

Approach:

Computer programs will be developed to further automate the process of converting NMR scan data to a mapping of the "unfolded" surface of the cerebral cortex. The value of this methodology will be investigated in a study of brain damaged patients who show spatial neglect -- an inability to attend to portions of the spatial world around them. The specifics of physical damage will be correlated with the extent and nature of the functional deficits they display. The reliability of the data conversion process will be investigated.

Progress:

An interactive program has been developed which extracts the cortical slice line on the original NMR images. The user can interactively call upon various contour enhancement techniques and can create and edit any portion of the slice line. Digitizing of the line data is automatic. A study of the reliability of estimates of cortical surface area in regions of interest has been done: results ranged from 3% variability for the frontal and temporal lobes to 15% for the occipital lobe, all better than the estimated reliability of the Van Essen and Maunsell method for post-mortem specimens. A method for obtaining a brain "slice" in any arbitrary orientation has been developed.

Report:

Jouandet, M.L., Tramo, M.J., Herron, D.M., Hermann, A., Loftus, W.C., Bazell, J. and Gazzaniga, M.S. (1989) Brainprints. J. Cognitive Neuroscience, 1, 88-116.

TITLE: Computer Based Assessment of Cognitive Abilities

PRINCIPAL INVESTIGATOR: Earl B. Hunt
University of Washington
Department of Psychology
(206) 543-8995

R&T PROJECT CODE: 4422538

CONTRACT NO: N0001486C0065

CURRENT END DATE: 15 SEP 1990

Objective:

The research objective is to conduct studies of individual differences in the ability to coordinate visual-spatial, verbal, auditory, and motor performance, including performance in dynamic tasks, and to determine whether there is an ability to coordinate information received across these modalities that is over and above the ability to deal with each modality separately. Such differences may reflect basic differences in individual cognitive capacities.

Approach:

Performance on multi-component tasks requiring coordination of information from multiple sources employing different modalities will be investigated using computer-based presentation and measurement. Carefully designed repeated measures experiments will be complemented by analysis of covariance procedures.

Progress:

Evidence has been obtained for the existence of specifically coordinative abilities when perceptual information of either a visual or auditory nature must be coordinated with verbal information. Novel measures of abilities to orient in large scale space have been developed. A preliminary study of the abilities of competitive orienteers has been completed.

Report:

P.L. Yee, E. Hunt, and J.W. Pellegrino, Coordinating cognitive information: Task effects and individual differences in integrating information from several sources. *Cognitive Psychology* (in press).

TITLE: Understanding the Immediate Interaction Cycle Using the Soar Unified Theory of Cognition

PRINCIPAL INVESTIGATOR: Bonnie E. John
Carnegie-Mellon University
School of Computer Science
(412) 268-2000

R&T PROJECT CODE: 4422556

CONTRACT NO: N0001489J1975

CURRENT END DATE: 30 JUN 1991

Objective:
To extend the Soar model of human cognitive architecture to account for the way in which interaction with perceivable and modifiable displays in the environment -- such as diagrams or computer displays -- serves to augment the limited working memory of human problem solvers and decision makers.

Approach:
Videotape protocols with good chronometric data will be collected while people perform tasks which involve constructing and modifying displayed objects on a computer. In addition, at least one non-computerized task, such as the use of a scratch pad while reasoning, will be studied. The information in the videotapes will be the basis for constructing a simulation model of this "immediate interaction cycle" within the Soar theory of cognitive architecture. Integration of display information with internal working memory will be emphasized in this theoretical effort.

Progress:
This project was initiated recently; a SOAR model of browsing a menu-driven software system has been completed.

TITLE: Imagery Processing in the Brain: What Neural Networks Compute

PRINCIPAL INVESTIGATOR: Stephen M. Kosslyn
Harvard University
Department of Psychology
(617) 495-3932

R&T PROJECT CODE: 4422551

CONTRACT NO: N0001490MP24010

CURRENT END DATE: 15 NOV 1990

Objective:
To conduct experimental studies of component processes involved in visual mental imagery, using four different research techniques, to converge on a comprehensive theoretical formulation which relates cognitive functions with their neural-system substrates.

Approach:
Studies of visual-imagery component-processing subsystems are conducted with normal observers and in patients with damage to one hemisphere of the brain, using tasks specially designed for these purposes. Brain electrical-activity mapping is employed to obtain convergent evidence for inferences drawn from the other types of data.

Progress:
The imagery abilities task battery (completed previously) was used for detailed examination of a patient with Broca's aphasia; theoretical predictions regarding additional properties of his imagery were confirmed. Brain-damaged patients also were tested to assess the contribution of the occipital lobe to visual imagery; evidence collected from this testing has been consistent with the claim that images are spatial representations supported by structures in the occipital lobe. Additional experiments with normal subjects produced evidence relevant to evaluating the object encoding theories offered by Biederman.

Report:
Kosslyn, S.M., Flynn, R.A., Amsterdam, J.B., Wang, G. (1990) Components of high-level vision: A cognitive neuroscience analysis and accounts of neurological syndromes. Cognition, 34, 203-207.

Outside Funding:
This project is jointly supported with The Air Force Office of Scientific Research.

TITLE: Components of Picture Naming

PRINCIPAL INVESTIGATOR: Stephen M. Kosslyn
Harvard College
Department of Psychology
(617) 495-5501

R&T PROJECT CODE: 4422560

CONTRACT NO: N0001490J1826

CURRENT END DATE: 14 APR 1991

Objective:
The objective of this project is to identify component processes involved in identifying visual objects.

Approach:
Using a novel adaptation of the additive factors technique, behavioral experiments will be conducted to seek evidence for the existence of independent subprocesses involved in the identification of visual objects. A computational analysis of object identification has been done, suggesting the existence of at least 12 such processes. The present work will provide a sound foundation for anticipated future studies in which PET scan studies of brain activity during object identification will be used to further test these hypotheses concerning the neural computation underlying human object identification.

Progress:
This grant is new in FY90.

TITLE: Conference on the Functional Imaging of the Human Nervous System

PRINCIPAL INVESTIGATOR: Guy M. McKhann
The Johns Hopkins University
The Mind/Brain Institute
(301) 338-8640

R&T PROJECT CODE: 4422558

CONTRACT NO: N0001489J3031

CURRENT END DATE: 31 JUL 1990

Objective:
To conduct a conference to consider how the new technologies for imaging brain activity can best be used to improve understanding of the way in which the brain implements its psychological information processing functions.

Approach:
Outstanding researchers familiar with both imaging technologies and the behavioral study of psychological functions will be brought together to discuss these issues.

Progress:
The conference was held June 29-30, 1990.

Outside Funding:
This award was jointly supported by ONR Code 1142CS and AFOSR.

COGNITIVE SCIENCE

KNOWLEDGE, SKILL AND EXPERTISE

TITLE: Stability in Conceptual Belief

PRINCIPAL INVESTIGATOR: Paul J. Feltovich
Southern Illinois University at Carbondale
Department of Medical Education
(217) 782-7878

R&T PROJECT CODE: 4422547

CONTRACT NO: N0001488K0077

CURRENT END DATE: 30 NOV 1990

Objective:

Research objectives are to develop a Conceptual Ability Scheme for characterizing misconceptions and for predicting their stability, to apply this scheme in predicting the stability of misconceptions about the cardiovascular system, to develop a Conceptual Stability Battery for determining the actual stability of each misconception among students, and to create computer network models of selected misconceptions to help account for variation in stability.

Approach:

The approach uses a combination of cognitive structure and process analyses based on the Conceptual Stability Scheme, empirical verification of the stability predictions using the Conceptual Stability Battery, and computer network modeling of selected misconceptions. This combination will permit insights into the structure and causes of misconceptions about complex phenomena both through theoretical and empirical studies of skilled human subjects and through manipulations of computer network models of the structures and processes which underlie those misconceptions.

Progress:

Materials have been developed for diagnosing the student's belief structure in the domain and for predicting the stability of erroneous conceptual beliefs. Substantial progress has been made in developing the instructional interventions needed for testing the theoretical hypotheses about the stability of (erroneous) belief structures. The diagnostic instrument is also being computerized.

Report:

Spiro, R. J., Coulson, R. L., Feltovich, P. J. and Anderson, D. K., (1988). Cognitive flexibility theory: Advanced knowledge acquisition in ill-structured domains. In The 10th Annual Conference of the Cognitive Science Society. Hillsdale, NJ: Lawrence Erlbaum Associates

TITLE: Questioning Mechanisms During Complex Learning

PRINCIPAL INVESTIGATOR: Arthur C. Graesser
Memphis State University
Depts. of Psychology and Mathematical Science
(901) 678-2742

R&T PROJECT CODE: 4422548

CONTRACT NO: N0001490J1492

CURRENT END DATE: 14 JAN 1992

Objective:
The objective of the research is to extend the QUEST computer simulation model of question answering to account for the interaction between human tutors and students. QUEST now models the process by which answers are generated from conceptual graph structures of knowledge.

Approach:
The interactions of human tutors and students during instruction in mathematical word problem solving and instruction in scientific research methods will be recorded, transcribed, and analyzed. Changes in the pattern of questioning over time will be related to existing theories of the process of knowledge acquisition. The QUEST computer simulation model will be extended to account for question asking and answering in the tutorial situation, with particular emphasis on pragmatic features of interaction related to shared and differential knowledge and goals.

Progress:
Extensive data on the generation and acceptability of answers to questions have been collected in order to test the QUEST model. A number of papers reporting this work have been prepared, including those cited below. A large body of tutorial interactions have been recorded and are now being analyzed with respect to both question generation and question answering processes.

Report:
Graesser, A.C. & Franklin, S.P. QUEST: A cognitive model of question answering. Discourse Processes (in press)
Golding, J.M., Graesser, A.C. & Millis, K.K. What makes a good answer to a question? Testing a psychological model of question answering. Discourse Processes (in press)

TITLE: Knowledge and Process for Design

PRINIPAL INVESTIGATOR: James G. Greeno
Leland Stanford Junior University
School of Education
(415) 723-0433

R&T PROJECT CODE: 4422549

CONTRACT NO: N0001488K0152

CURRENT END DATE: 31 JAN 1991

Objective:
The research objective is to conduct studies of the design problem-solving process which will yield data for developing a model that characterizes the contents of the problem space and the problem-solving processes involved in design tasks, focusing on generative processes of formulating and modifying problem goals and plans and on using information from multiple sources.

Approach:
Experimental subjects are asked to design instruction, given some goals and constraints. Empirical studies and psychological experiments will be conducted in which goals and constraints on design problems are manipulated, and in which the availability of knowledge relevant to the design task is varied. The primary instructional design topic to be studied is training in the operation of artificial devices. Designers' knowledge of the subject matter is controlled through instruction given to them, and the designer's amount of background in educational theory is a variable.

Progress:
Protocol data have been collected from 12 particpant designers, transcribed and coded using a scheme collaboratively developed with Peter Pirolli of Berkeley. The problem space of design has been found to include several subproblems, which involve different aspects of the design. Subproblems of design differ from those in many problem solving tasks in that they seem to be continuously active and applying simultaneously in the solution of the problem, rather than being solved successively in isolation.

Report:
Greeno, J.G., Korpi, M.K., Jackson, M.K., & Michalchik, V.S. (1990) Processes and knowledge in designing instruction. Technical Report, Stanford University.

TITLE: Analysis of the Organization of Lexical Memory

PRINCIPAL INVESTIGATOR: George A. Miller
Princeton University
Department of Psychology
(609) 452-5973

R&T PROJECT CODE: 442c026

CONTRACT NO: N0001490J1692

CURRENT END DATE: 28 FEB 1991

Objective:

The objective is to develop a novel kind of electronic lexical reference work, an augmented thesaurus, that is built upon a model of human lexical memory, in order to facilitate tasks in which the relationships of word meanings are important: design of technical and instructional documents, reading and use of such documents, and natural language computer interfaces.

Approach:

A computer simulation of human lexical memory is being constructed. A master list of words is being used to simulate phonological access. Lexical concepts are represented as synonym sets. These lexical concepts are being extensively interconnected by networks of meaning relationships: opposition of meaning, part-whole relations, and subordination relations.

Progress:

The WordNet database now contains 32,264 nouns with 43,136 senses; 5,885 verbs with 8,475 senses, and 12,909 adjectives. Work has begun on integrating the part-whole relations with the noun superordinate-subordinate hierarchy. Experiments have been conducted to test the psychological validity of the novel organization developed for the adjective files. Work on a program to aid writers in filtering out rare words is in progress.

Reports:

Miller, G. A., Fellbaum, C., Kegl, J., and Miller, K. (1988) WordNet: An electronic reference system based on theories of lexical memory. Revue québécoisé de linguistiqué, 17, 181-213.

Gross, D., Fischer, U., & Miller, G. A. (1989) The organization of adjectival meanings. Journal of Memory and Language, 28, 92-106.

Outside Funding:

Funds for this project are provided by the Navy Personnel Research and Development Center and ONT Code 222.

TITLE: Knowledge and Processes for Design

PRINCIPAL INVESTIGATOR: Peter Pirolli
University of California, Berkeley
Department of Education
(415) 652-4206

R&T PROJECT CODE: 4422550

CONTRACT NO: N0001488K0233

CURRENT END DATE: 31 DEC 1990

Objective:
The research objective is to conduct studies of the design problem-solving process which will yield data for developing a model that characterizes the contents of the problem space and the problem-solving processes involved in design tasks, focusing on generative processes of formulating and modifying problem goals and plans and on using information from multiple sources.

Approach:
The approach uses a variety of design tasks, emphasizing instructional design, but including other types of design for purposes of comparison. Subjects are asked to design instruction, given certain goals and constraints. Empirical studies and psychological experiments will be conducted in which goals and constraints on design problems are manipulated, and in which the availability of knowledge relevant to the design task is varied. Some aspects of design problem solving performance are being modeled in the SOAR cognitive architecture.

Progress:
A study of instructional design has been conducted in which protocols were collected from professional instructional designers employed by an international office systems company, designing instruction in a familiar word- processing system under a variety of different conditions. Similar protocols have been collected for comparative purposes from an architect and a mechanical engineer. A general conceptual framework for design problem solving has been developed and related to a formalism for protocol analysis. A Soar simulation of an individual designer has been completed.

Report:
Goel, V. & Pirolli, P. (1989). Motivating the notion of generic design within information processing theory: the design problem space. AI Magazine, 10, 18-36.

COGNITIVE SCIENCE

LEARNING AND INSTRUCTION

TITLE: The Induction of Mental Structures While Learning to Use Symbolic Systems

PRINCIPAL INVESTIGATOR: Thomas G. Bever
University of Rochester
Department of Psychology
(716) 275-3213

R&T PROJECT CODE: 442f005

CONTRACT NO: N0001488K0336

CURRENT END DATE: 30 APR 1991

Objective:
The research objective is to explore the emergence of implicit mental structures (such as linguistic grammars or mental models of machine operations) during the solution of explicit problems. The investigator has proposed a problem-solving theory of the acquisition of implicit structure which he will test with a series of experiments using an artificial symbolic system.

Approach:
A series of experiments will be conducted to test hypotheses derived from the investigator's theory of the formation of implicit mental structures during the solution of explicit problems. In addition to attempting to improve the efficiency of the basic paradigm used in a pilot study, the experiments will investigate: implications, for learning, of conflicting regularities within mapping systems for internal perception and production mechanisms; differences between perception and production in learning; and extensions of the paradigm to investigate implications of fuzzy feedback, effects of error messages, and modelling of the acquisition of behavior and structure.

Progress:
Six new experiments were run in which the results of the experiments that formed the basis of the proposal were replicated, and improved understanding of the conditions necessary to obtain those results was achieved. Computer programs to improve the quality of experimental stimulus presentations have been developed. A preliminary version of a connectionist learning model to account for the results has been developed. A new paradigm, based on study of map learning, has been develop for investigating induction of abstract mental representations.

TITLE: The Improvement of Text Readability by Phrase-Sensitive Formatting

PRINCIPAL INVESTIGATOR: Thomas G. Bever
University of Rochester
Department of Psychology
(716) 275-3213

R&T PROJECT CODE: 4428016

CONTRACT NO: N0001489J3032

CURRENT END DATE: 30 JUN 1991

Objective:
The research objective is to determine whether text formatted so as to indicate phrase boundaries, using an automated algorithm to determine phrase boundaries, will improve the readability of text.

Approach:
Carefully designed experiments with community college subjects of different levels of reading ability will be conducted to examine the influences and interactions of several variables on reading speed, comprehension, and retention. The variables include reading ability, text complexity, phrase size, space size, and retention interval; other variables suggested by these experiments may also be studied. The phrase size and space size variables will be controlled by an algorithm for automatically formatting text which has been developed and tested by the PI.

Progress:
Several hundred subjects have been tested on phrase structure formatted essay comprehension items. Formatting led to significantly better performance on test items, as well as faster reading times. Effects are largest for below-average readers and difficult essays. Texts treated to maximize the evenness of the number of words also improve reading performance; in this case, the advantage is primarily seen for above average readers.

Report:
Bever, Jandreau, Burwell, Kaplan & Zaenen, Spacing printed text to isolate major phrases improves readability. (submitted)

Outside Funding:
Funds for this project are provided by ONT Code 222 and the Navy Personnel Research and Development Center.

TITLE: Understanding Mechanical Systems Through Computer Animation and Kinematic Imagery

PRINCIPAL INVESTIGATOR: Patricia A. Carpenter
Carnegie-Mellon University
Department of Psychology
(412) 268-2091

R&T PROJECT CODE: 4428017

CONTRACT NO: N0001489J1218

CURRENT END DATE: 30 NOV 1991

Objective:
Determine how computer animations can be used in training to enhance understanding of the operation of mechanical devices.

Approach:
Conduct behavioral experiments in which device and display characteristics are systematically varied, while eye movements are monitored and subject ability to answer questions about device operation is measured. Build computer simulation models of the process of device understanding that account for these data.

Progress:
A series of experiments examined the relation between the degree of mechanical constraint in simple devices and the accuracy and speed of mental animation. Individual difference results suggest that mechanical knowledge influences the accuracy with which a mechanical device can be analyzed, whereas spatial ability influences the speed and accuracy with which trajectories of moving parts are internally computed. Device animations were found to enhance the performance of low mechanical ability subjects but to result in less accurate performance by high mechanical ability subjects. Efforts to have computer animations compensate for low mechanical ability, however, have not yet been successful, and that goal continues to be pursued.

Report:
Fallside, P. & Just, M. (1989) Understanding a machine in motion. Technical Report, Carnegie-Mellon University.

Outside Funding:
Funds for this project are provided by ONT Code 222.

TITLE: Computer Generation of a Tutorial Dialogue

PRINCIPAL INVESTIGATOR: Martha Evens
Illinois Institute of Technology
Department of Computer Science
(312) 567-5153

R&T PROJECT CODE: 4422554

CONTRACT NO: N0001489J1952

CURRENT END DATE: 14 NOV 1990

Objective:
The objective of this grant is to learn how to produce intelligent computer-generated tutorial dialogue.

Approach:
The tutorial guidance provided by expert human tutors working with students using an instructional simulation will be recorded and analyzed. The approach to generating text will be similar to that taken by the AI group at U. Mass Amherst -- McKeown, McDonald, and Woolf -- but the Lexical Functional grammar of Kaplan and Bresnan will be used with lexical selection based on Even's previous lexical work. In addition, information taken from the student model of the tutoring system will be used to individualize the tutorial dialog appropriately for student needs.

Progress:
Tutoring sessions, presenting expert human tutors working with students, have been recorded and are being transcribed for analysis.Software development also has been initiated for the system that will support automated generation of similar natural language tutorial interaction.

TITLE: Analogical Processes and Learning in Physical Domains

PRINCIPAL INVESTIGATOR: Dedre Gentner
University of Illinois
Department of Psychology
(217) 333-2186

R&T PROJECT CODE: 442f007

CONTRACT NO: N0001489J1272

CURRENT END DATE: 30 NOV 1992

Objective:
The goal is to construct and test a general theory of analogical thinking as it occurs in both learning and reasoning. Parametric investigations of the detailed assumptions of the formal model of this theory, the Structure Mapping Engine, will be conducted in order to more precisely specify detailed aspects of the theory. More aspects of the application of the theory will be automated in order to increase its objectivity, and its application to the new and more complex domain of the learning of causal models will be explored.

Approach:
Psychological and computational experiments will be conducted in parallel to determine what computational theory can best account for human data on learning, analogy formation, and analogy evaluation. The learning of causal models for physical phenomena in artificial worlds will be an important aspect of the psychological investigations.

Progress:
A study has been completed on the relationship of verbalization of a task and ability to transfer that task; results indicate that verbalization prior to transfer attenuated the transfer difficulty associated with conflicting superficial similarities. A programmable system also has been built for experimenting with two-stage models of similarity-based access from long-term memory.

Report:
Clement, C., & Gentner, D. (1990, in press) Systematicity as a selection constraint in analogical mapping. Cognitive Science.
Falkenhainer, B., Forbus, K.D. & Gentner, D. (1989/1990) The structure-mapping engine: algorithm and examples. Artificial Intelligence, 41, 1-63.

TITLE: Qualitative Simulation and Intelligent Tutoring Aids

PRINCIPAL INVESTIGATOR: T. Govindaraj
Georgia Tech Research Corporation
School of Industrial and Systems Engineering
(404) 894-3873

R&T PROJECT CODE: 4428004

CONTRACT NO: N0001487K0482

CURRENT END DATE: 31 DEC 1990

Objective:
Formalize a method for qualitative simulation of complex dynamic systems. Integrate a moderate-fidelity qualitative marine powerplant simulation with a blackboard-based instructional planning system to produce a prototype intelligent tutoring system and problem-solving aid for marine powerplant troubleshooting and maintenance. Test and refine the tutoring and simulation architecture.

Approach:
Conduct fault diagnosis experiments using an existing moderate fidelity marine powerplant simulator. Enhance the simulator by incorporating operator inputs. Using the improved simulator, conduct further fault diagnosis and compensation experiments. Implement and experimentally evaluate an intelligent tutor-associate, using college, NROTC and Merchant Marine subjects at varying levels of expertise.

Progress:
The simulation component of the powerplant tutor has been ported to the MacII, with color graphics added. In the process, tools for building the active regions needed in interactive interfaces were created and can be made available to others. The tutor is complete and training experiments are beginning.

Report:
Vasandani,V., Govindaraj, T., & Mitchell, C.M. (1989). An Intelligent Tutor for Diagnostic Problem Solving in Complex Dynamic Systems. In the Proceedings of the IEEE International Conference on Systems, Man, and Cybernetics, November 14-17, Cambridge, MA, pp. 772-777.

Outside Funding:
Funds for this project are provided by ONT Code 222.

TITLE: Explanation and Decision Making in Planning

PRINCIPAL INVESTIGATOR: Kristian J. Hammond
University of Chicago
Department of Computer Science
(312) 702-1571

R&T PROJECT CODE: 442f003

CONTRACT NO: N0001488K0295

CURRENT END DATE: 14 NOV 1990

Objective:
The objective is to develop a theory of case-based reasoning for problem-solving tasks that addresses questions of memory organization, of decision-making as it applies to the selection of past cases for use in problem-solving, and of the role of explanation formation in learning from case experience.

Approach:
AI programs aredeveloped that constitute an elaborate hypothesis about the nature of the case-based reasoning process involved in solving such problems: a Problem Anticipator that recalls planning problems in past similar situations, a Case Retriever that searches for a plan that satisfies as many goals as possible while avoiding anticipated problems, a Case Modifier that alters the retrieved plan to satisfy additional goals, a Plan Repairer that generates causal explanations for failures repairs plans on that basis, a Case Storer that indexes plans in memory according to the goals they satisfy and the problems they avoid, and a Blame Assigner that uses causal explanations of failure to identify features to predict and avoid similar failures in the future. Psychological experiments will be used to investigate alternative hypotheses that arise as design issues in the model.

Progress:
Four case-based systems have been developed. Several related experiments have been conducted.

Report:
Hammond, K. (1990, in press) Case-based planning: A framework for planning from experience. Cognitive Science.
Siefert, C.M. & Hammond, K. (1990) Intelligent encoding of cases. Proceedings of the AAAI Spring Symposium Series on Case-Based Reasoning.

Outside Funding:
The project is jointly funded by ONR Codes 1142CS and 1133 (Computer Science).

TITLE: Explanation-Based Acquisition of Electronics Knowledge

PRINCIPAL INVESTIGATOR: David Kieras
University of Michigan, Ann Arbor
Technical Communication Program
(313) 763-6739

R&T PROJECT CODE: 442f002

CONTRACT NO: N0001488K0133

CURRENT END DATE: 31 OCT 1990

Objective:
An AI system is constructed for learning electronics concepts from explanatory text and cognitive-psychology experiments on human learning conducted within the same context. Results of the two types of investigations are integrated in the form of a cognitive model that explains human acquisition of knowledge in this domain in terms of the mechanisms in the AI system.

Approach:
The system is augmented by additional rules on the behavior of AC circuits in the processing of signals, such as the time structure of the system (history of the previous states of the circuit), multiple events, and representations of the states of the circuit. Learning and schema formation rules are developed from prior rules. The system is implemented in Common LISP. Cognitive models of these processes are developed that provide predictive metrics, and are experimentally evaluated.

Progress:
AI explanation-based learning programs have been written and are being used to verify that instructional materials accurately represent the desired experimental conditions; indices of processing effort that the AI programs provide also are being used to predict human reading and response times.

Report:
J. H. Mayer (1990) Explanation-based knowledge acquisition of schemas in practical electronics: A machine learning approach. University of Michigan.

TITLE: Concept Formation Symposium

PRINCIPAL INVESTIGATOR: Patrick Langley
Institute for the Study of Learning & Expertise
(714) 856-6556

R&T PROJECT CODE: 433g016

CONTRACT NO: N0001490J1394

CURRENT END DATE: 30 NOV 1990

Objective:
The objective is to provide a forum for the exchange of information on current and planned research in the topic of concept formation, i. e., the unsupervised and incremental acquisition of conceptual knowledge.

Approach:
A Symposium on Concept Formation will be held at Stanford University, 6-7 January 1990. There will be approximately 60 invited participants, and a volume of presented papers will be published. The American Association for Artificial Intelligence will co-sponsor the Symposium, as will NSF.

Progress:
The previous Symposium held in 1989 focussed on the automation of reasoning in scientific discovery, and provided a comprehensive review of current and planned research in hypothesis and theory formation in discovery processes.

Outside Funding:
This symposium was jointly funded by ONR Codes 1142CS and 1133 (Computer Science).

TITLE:	Schemas in Problem Solving: An Integrated Model of Memory, Learning, and Instruction
PRINCIPAL INVESTIGATOR:	Sandra P. Marshall San Diego State University Foundation Department of Psychology (619) 594-2695
R&T PROJECT CODE:	442c010
CONTRACT NO:	N0001490J1143
CURRENT END DATE:	30 SEP 1991

Objective:
The project objective is to produce a psychological model of the teaching and learning of mathematical problem-solving skills, incorporating three components: a model of knowledge in memory, a model of learning, and a model of instruction. The model of instruction, unlike most, will be explicitly related to the psychological models of learning and memory for this problem domain. It is a test of the value of schema theories of knowledge and skill.

Approach:
The underlying semantic structures, or schemas, of mathematics word problems used in school texts, Navy remedial courses, and standardized tests have been analyzed and related to item difficulty in mass test data. Computer simulations of problem-solving knowledge and skill will provide the basis for experimental instruction, and the process of learning will also be modeled in a computer simulation. Further instructional/learning experiments will be conducted to test aspects of the computer simulation model.

Progress:
Eleven tasks proposed in the original proposal and a previous renewal have been completed, including a) the development of a detailed theory of problem schemata that has been shown to cover the problems commonly used in instruction, including Navy remedial math instruction; b) computerized instruction based on the schema theory has been constructed; c) instructional experiments have been conducted with detailed protocols collected to probe what is being learned; d) initial models of learning have been built, suggesting that further modeling within a partially connectionist framework would be appropriate.

Report:
Marshall, S. P., Barthuli, K.E., Brewer, M. A., & Rose, F.E. (1989). The Story Problem Solver: A schema-based instructional system. Tech. Rep. Contract No. NOO014-85-K-0661.

TITLE: Human Plausible Reasoning and Learning
Development of a Computational Model and Unified
Theory.

PRINCIPAL INVESTIGATOR: Ryszard S. Michalski
George Mason University
Computer Science Department
(703) 323-2713

R&T PROJECT CODE: 442f006

CONTRACT NO: N0001488K0397

CURRENT END DATE: 14 MAY 1990

Objective:
This research aims to provide computational models of the way in which humans learn and reason with imprecise, incomplete and/or indirectly relevant premises.

Approach:
A unified theory of human plausible reasoning and inductive learning will be developed in the form of a computational model. This will build upon the Collins and Michalski "core theory" of human plausible reasoning, upon Michalski's "two-tiered method" for representing flexible context-dependent concepts, and Medin's "multi-criterion patch model" of inductive learning. Further experimental tests of human performance will be conducted in order to test the computational theory against human performance.

Progress:
The theory of plausible reasoning was implemented as a computer program, enabling the derivation of predictions of human performance. A series of experiments with human subjects was conducted and analyzed in terms of the concepts and inference rules of the theory. The results support the basic tenets of the theory, demonstrating that the proposed structural organization of knowledge and multi-pattern inference play a crucial role in plausible reasoning.

Report:
Collins, A. and Michalski, R. (1989) The logic of plausible reasoning: A core theory, Cognitive Science, 13.

TITLE: Knowledge Based Revision of Cognitive Procedures in Response to Changing Task Demands

PRINCIPAL INVESTIGATOR: Stellan Ohlsson
University of Pittsburgh
Learning Research and Development Center
(412) 624-7460

R&T PROJECT CODE: 442f008

CONTRACT NO: N0001489J1681

CURRENT END DATE: 28 FEB 1991

Objective:
The objective is to understand how knowledge of principles in a domain can be used to aid learning and adaptive modification of problem-solving procedures.

Approach:
Computer simulations will be built to determine how principled knowledge can be used to monitor, acquire, and adapt procedures. Two domains in which extensive human problem-solving data are available will be explored -- arithmetic and physics problem-solving. Variations in the models will be used to determine how these variations affect the efficiency of learning. In particular, learning mechanisms proposed in various important cognitive theories of learning -- chunking (Newell), knowledge compilation (Anderson) and explanation-based learning (DeJong) -- will be compared for their impact on overall learning performance.

Progress:
A computer simulation of knowledge-based revision of cognitive procedures has been constructed. It is being tested in the domain of simple arithmetic tasks, and has been shown to be capable of learning (and learning transfer). Quantitative comparison of its learning performance with that of other systems also has been initiated.

Report:
Ohlsson, S. (1990) The mechanism of restructuring in geometry. Technical Report, University of Pittsburgh.
Ohlsson, S. & Rees, E. (1990) Adaptive search through constraint violations. Technical Report, University of Pittsburgh.
Ohlsson, S. & Rees, E. (1990) Comparative evaluation of knowledge-based simulation models of procedural learning. Technical Report, University of Pittsburgh.

TITLE: Seventh International Conference on Machine Learning

PRINCIPAL INVESTIGATOR: Bruce Porter
The University of Texas at Austin
Department of Computer Science
(512) 471-7316

R&T PROJECT CODE: 433g022

CONTRACT NO: N0001490J1610

CURRENT END DATE: 28 FEB 1991

Objective:
The objective is to provide a forum for presentation of recent research results and discussions of research directions in the area of Machine Learning.

Approach:
The approach is to hold the Seventh International Conference on Machine Learning, 21-23 June 1990, at the University of Texas, Austin. Twenty-five refereed technical papers will be presented, as well as three or four invited talks by Distinguished Speakers. A Proceedings will be published by Morgan Kaufman, Inc.

Outside Funding:
This project was jointly funded by ONR Codes 1142CS and 1133 (Computer Science).

TITLE: Impact of Intelligent Computer-Assisted Instruction

PRINCIPAL INVESTIGATOR: Janet W. Schofield
University of Pittsburgh
Department of Psychology
(412) 624-3068

R&T PROJECT CODE: 442c013

CONTRACT NO: N0001485K0664

CURRENT END DATE: 31 DEC 1991

Objective:
Conduct research to test theoretically derived hypotheses concerning the impact of the introduction of an intelligent computer tutor upon the authority structure of the classroom and the content of the human instructor's role.

Approach:
Structured observations of both experiemental and conventional classrooms were the primary method of data collection, supplemented by observations of administrative meetings and interviews of participants. Observational records were stated in concrete, behavioral terms, and were transcribed and entered into a computer data base to facilitate both qualitative and qauntitative analyses.

Progress:
In the first two years of the project, observations were conducted in the experimental computer tutor classes, in "control" geometry classes, and in two computer science classes. Observations were conducted in other situations of school computer use as well. In addition, extensive interviews with students, teachers, and other project participants were conducted. The observational data have been computerized and analysis is in progress, with a book as the expected final product.

Report:
Schofield, J.W. & Verban, D. (1988) Computer usage in the teaching of mathematics: Issues which need answers. In D. Grouws & T. Cooney (Eds.), Perspectives on research on effective mathematics teaching (Volume 1). Hillsdale, NJ: Lawrence Erlbaum Associates.
Schofield, J. & Evans-Rhodes, D., (1989) Artificial Intelligence in the Classroom: The impact of a computer-based tutor on teachers and students. Technical Report, University of Pittsburgh.

TITLE: A Model of Self-Generated Explanation in Skill Acquisition

PRINCIPAL INVESTIGATOR: Kurt A. VanLehn
Carnegie-Mellon University
Dept. of Psychology
(412) 268-4964

R&T PROJECT CODE: 442f001

CONTRACT NO: N0001488K0086

CURRENT END DATE: 31 DEC 1990

Objective:
This project tests the hypothesis that self-generated explanations of the steps in example problems will permit more effective learning by building a set of computer simulation models of the process of learning from example problems in physics instruction.

Approach:
A previous grant to M. Chi generated protocol data from more and less effective learners of physics. A set of simulation models, which can also be regarded as examples of machine learning, will be developed to model the detailed protocols of individal students. A simulation program is built with these modules: 1) primitives corresponding to the protocol coding that establish the grain-size of modeling; 2) a non-analogical problem-solver for single-schema (simple) problems; 3) explanation of problem statements that classifies problems appropriately into types; 4) explanation of problem solutions that justifies problem solving actions; 5) analogical problem-solving and learning; and 6) a problem solver for complex multi-schema problems.

Progress:
A new machine-learning technique (Plausible Explanation Completion) is being used to analyze and simulate protocol data from students who are learning physics by working problems and studying examples. A 200-rule knowledge base was constructed by the researchers, and Plausible Explanation Completion has independently generated some of the rules it contains in a way that approximates student learning behavior.

Report:
VanLehn (1989) Learning events in the acquisition of three skills. Proceedings of the 11th Annual Conference of the Cognitive Science Society.
VanLehn (1989) Discovering problem solving strategies: What humans do and machines don't (yet). Proceedings of the 1989 Machine Learning Workshop.

TITLE: Automating Knowledge Acquisition

PRINCIPAL INVESTIGATOR: David C. Wilkins
University of Illinois
Dept. of Computer Science
(415) 725-3850

R&T PROJECT CODE: 433g008

CONTRACT NO: N0001488K0124

CURRENT END DATE: 30 NOV 1990

Objective:
The objective is to understand how learning within knowledge based systems can be extended to include the refinement and debugging of knowledge.

Approach:
The approach will be to employ learning apprentice strategies which allow the system to monitor and analyze human decision making in the course of solving problems. An automated system (ODYSSEUS) will serve as a testbed for studying alternative approaches to identifying the presence of errors in a knowledge base and assessing the merits of candidate repairs. Insights into the performance limits of apprentice learning systems will be sought by examining the capability of ODYSSEUS relative to the observed procedures and performance of human experts.

Progress:
Progress has been made in the identification of powerful strategies for handling three types of domain theory pathologies: incorrectness, inconsistency, and incompleteness. These strategies are based upon connections between the primary domain theory and underlying domain theories, and an explicit, modular, and declarative representation for the domain theory.

Report:
Wilkins, D. C. Knowledge Base Refinement Using Apprenticeship Learning Techniques, Proceedings of the 1988 National Conference on Artificial Intelligence.

Outside Funding:
This project was jointly funded with ONR Code 1133, Computer Science.

COGNITIVE SCIENCE

MODEL-BASED MEASUREMENT

TITLE: Conditional Dependence

PRINCIPAL INVESTIGATOR: Robert D. Gibbons
University of Illinois at Chicago
Department of Psychiatry
(312) 413-1357

R&T PROJECT CODE: 4421553

CONTRACT NO: N0001489J1104

CURRENT END DATE: 30 NOV 1991

Objective:
Recently, this investigator used an approximation technique based on the so-called Clark algorithm to obtain estimates of pattern probabilities which are robust to violations of conditional independence. This project is extending that work to new contexts. These include modelling performance on long tests (perhaps 50 items in length), on adaptive tests, on tests scored polychotomously, and on tests composed of several homogeneous subtests.

Approach:
Several techniques for estimating the residual covariances will be studied. These include: (a) using the sample tetrachoric correlations, (b) using the expected covariances from a higher dimensional solution, and (c) fitting specific patterned structures (e.g., first-order autocorrelation, block-diagonal, etc.). The viability of these approaches will be studied using simulated and real test data. Finally, a unidimensional polychotomous model for multidimensional data sets will be developed.

Progress:
(a) Preliminary work on extending this approach to longer tests has focused on developing an EM solution and on implementing a ridge-like adjustment to stabilize a final Newton-Raphson step. The viability of these techniques is being examined using data from the American College Testing Programs. (b) An empirical comparison between the results of TESTFACT and Formula Score Theory is underway. And, (c) the implementation of some of the heavy computations needed on a parallel board is under development.

Report:
Gibbons, R.J., Bock, R.D., and Hadecker, D. (1990) Approximating Multivariate Normal Probabilities Over Rectangular Regions. Biometric lab report 90-1.

TITLE: Latent-Trait Representations of Behavioral Data

PRINCIPAL INVESTIGATOR: Paul W. Holland
Educational Testing Service
(609) 921-9000

R&T PROJECT CODE: 4421551

CONTRACT NO: N0001487K0730

CURRENT END DATE: 31 JUL 1990

Objective:
The Dutch identity provides a way of rewriting the basic equations of IRT models that suggests that all sufficiently smooth IRT models for dichotomous data are approximate log-linear models. The approximation improves as the number of items increases. These log-linear models have only two-way interactions and these interactions are restricted by the dimensionality of the latent trait. The objective of this project is to empirically test those predictions.

Approach:
Data were generated from a Rasch model and a third order polynomial was fit to the log of the resulting pattern relative frequencies. Test lengths of 20, 30, 40, 60, 80, and 100 items were simulated. In every case 30,000 examinees were used.

Progress:
The predictions of the Dutch identify were generally supported by the simulation results.

Report:
Holland, P.J. (1990) The Dutch identity: A new tool for the study of item-response models. Psychometrika, 55, 1-18.

TITLE: Item-Calibration Procedures for Military Computer Adaptive Testing: Statistical Empirical Design

PRINCIPAL INVESTIGATOR: Douglas H. Jones
Thatcher Jones Associates
(609) 895-0924

R&T PROJECT CODE: 4428007

CONTRACT NO: N0001487C0696

CURRENT END DATE: 31 DEC 1990

Objective:
This project is investigating alternatives to the random assignment of items to examinees in item-response-theory calibration studies. The aim is to develop procedures to adaptively gather data on new items. Issues under investigation include: (a) How to incorporate what is known about the unknown in arriving at optimal designs. (b) What sorts of optimality criteria should be used? (c) What to do when "optimal" examinees are not presently available? (d) How might optimal design solutions differ for preliminary item tryout and for fine tuning of the calibrations? (e) Which computational algorithms are most efficient in obtaining optimal designs?

Approach:
Theoretical work will extend optimal design theory and develop methods for dealing with model uncertainty. Numerical work will compare the efficiency of numerical algorithms. Experimental work will investigate the issue of item-person discordance.

Progress:
Theoretical development of the design model has been completed. The central problem concerning unknown control parameters has been solved using recent results from research on the measurement-errors-in-variables problem in non-linear response models. The designs are to be obtained by integer programming techniques. A technique that guarantees optimal designs has been developed. Simulation studies of the performance of the optimal design in an on-line computerized test is in progress.

Report:
Armstrong, R., Jones, D.H., & Wu, Ing-Long. (1990) An Automated Procedure for Test Development of Tests Parallel to the Seed Test. (Tech Rep.) Graduate School of Management, Rutgers University.

Outside Funding:
Funds for this project are provided by ONT Code 222.

TITLE: Structural Robustness and Local Dependence in Item Response Theory

PRINCIPAL INVESTIGATOR: Brian Junker
University of Illinois
Department of Statistics
(217) 333-2186

R&T PROJECT CODE: 4421560

CONTRACT NO:

CURRENT END DATE: 30 SEP 1990

Objective:

This project seeks to extend Stout's essential independence framework in several directions. First, it seeks a more complete trait estimation theory and trait-distribution estimation theory for tests which are only essentially unidimensional. Second, it seeks an item-response-function estimation theory. Third, it seeks necessary and sufficient conditions on observables for a test to be strictly unidimensional. Fourth, it will explore the theoretical relationships between classes of local dependence structure and multidimensionality.

Approach:

Initial work will (a) explore Kullbach-Leibler information distance function as a vehicle for studying the optimality of item-response functions in an essential-independence framework; (b) explore the theoretical connections between Sympson's polyweighting and efficient estimation of the dominant trait for essentially unidimensional tests; and, (c) empirically explore a novel approach to trait distribution estimation and compare it with extant procedures (especially, Mislevy's).

Progress:

This grant is new in FY90.

TITLE: Expert Knowledge Structures and Their Role in Cognitive Task Performance.

PRINCIPAL INVESTIGATOR: Richard J. Koubek
Wright State University
Dept of Biomedical and Human Factors Engin.
(513) 873-2701

R&T PROJECT CODE: 4421558

CONTRACT NO: N0001490J1256

CURRENT END DATE: 31 OCT 1992

Objective:
This research is exploring differences in high-level cognitive skill based on individual differences in the knowledge representation of a complex cognitive domain. The main task is the development of a model of and a paradigm for externalizing the effect of an individual's acquired representation of domain knowledge on skilled performance.

Approach:
An initial study involving students learning a word-processing task will explore the relationship between training variables, acquired representation, and performance as a function of task type. A second study will develop a taxonomy of expert knowledge representation types and will examine the suitability of each type for performing generic subtasks within that domain. A third study will examine the relationships between global cognitive abilities and features of an individual's acquired representation.

Progress:
Preliminary quantitative measures of knowledge representation have been developed for use in conjunction with multidimensional scaling techniques. Cognitive style interacts with training style to affect the acquisition of skill on a simple-repetitive task. Measured representation characteristics significantly influence performance on both complex and simple-repetitive cognitive tasks. Based on these findings, further development of a quantitative knowledge representation measurement technique is underway, together with developing a taxonomy of knowledge representation types.

Report:
Koubek, R.J. and Mountjoy, D.N. (1990). The role of training, individual differences and knowledge representation in operator skill acquisition for advanced manufacturing environments. In (W. Karawowski and M. Rahimi, Eds.) Ergonomics of Advanced Manufacturing and Hybrid Automated Systems II. Amsterdam: Elcvicr.

TITLE: Formula Scoring, Applications and Foundations

PRINCIPAL INVESTIGATOR: Michael V. Levine
University of Illinois
Department of Educational Psychology
(217) 333-0092

R&T PROJECT CODE: 4421546

CONTRACT NO: N0001498K0482

CURRENT END DATE: 31 DEC 1989

Objective:
This work will extend, refine,and apply Maximum-likelihood Formula Score Theory (MFS).

Approach:
(a) Derive asymptotic distributions of MFS estimates. (b) Develop an objective method for gauging the goodness of fit of MFS models. (c) Circumvent requirement for a well-estimated old-test. (d) Extend MFS to two dimensions. (e) Develop an MFS framework for equating CAT to linear tests.

Progress:
(a) Large-sample theory of MFS estimates have been derived. (b) A scale free technique for comparing the goodness-of-fit of alternative IRT models has been developed. (c) Two approaches were developed to circumvent the requirement for a well-estimated old-test. The first, iteratively re-estimates the old-test response functions, while holding the ability density constant. The second is an entirely new theory, Algebraic Formula Score Theory (AFS), which is based on the test manifold and does not require an old-test. (d) The practicality of multidimensional MFS techniques was substantially improved by introducing constraints. (e) An MFS framework for equating two tests has been developed.

Report:
Levine, M.V. (1989) Formula Scoring, Basic Theory and Applications. Report 89-1, Model Based Measurement Laboratory, Champaign: University of Illinois.

TITLE: New Tools for New Tests

PRINCIPAL INVESTIGATOR: Michael V. Levine
University of Illinois
Department of Educational Psychology
(217) 333-2186

R&T PROJECT CODE: 4421562

CONTRACT NO: N0001490J1958

CURRENT END DATE: 14 APR 1993

Objective:
Two general approaches for modelling multidimensional performance on cognitive tasks are being developed: Maximum-likelihood (MFS) and algebraic (AFS) formula-score theories. MFS will be a tool for checking hypotheses about information processing on complex tasks. Abstract manifolds from AFS will be a vehicle for obtaining representations of performance. The computer algorithms for both approaches are to be refined.

Approach:
A variety of constraints suggested by cognitive process models in specific task domains are being explored to reduce the estimation space for item response functions. These include smoothness constraints, monotonicity constraints, and explicit functional form constraints for task domains with sufficiently strong psychological theory. Initial work on AFS will explore low-dimensional parameterizations of test manifolds, improvements to numerical algorithms, and exploration of the viability of the AFS approach for specific modelling applications.

Progress:
It has been shown that manifolds for the most commonly used multidimensional test models, the "cylindrical models" have special properties that can be experimentally tested. Additionally, an algorithm for solving the functional equations for two-dimensional cylindrical models has been found. As a result the essentially unique item response functions from cylindrical manifolds can now be computed.

TITLE: Polychotomous Measurement for ASVAB

PRINCIPAL INVESTIGATOR: Michael V. Levine
University of Illinois
Department of Educational Psychology
(217) 333-0092

R&T PROJECT CODE: 4428020

CONTRACT NO: N0001489K0059

CURRENT END DATE: 14 FEB 1991

Objective:
This research is integrating, contrasting and evaluating extant polychotomous models. Parametric models under study include Bock's nominal model, Samejima's model, and Thissen's model. Nonparametric models include Levine's formula-score theories, Samejima's condition; PDF methods, and Sympson's polyscore approach.

Approach:
There are three lines of attack: Refinement of methods, conceptual integration, and empirical comparison with simulated and real data.

Progress:
Initial work has focused on the three parametric approaches and on Levine's maximum-likelihood formula score approach (MFS). All models were fit to both ASVAB and SAT data sets. For ASVAB data Samejima's parametric model fit quite well; some lack of fit was apparent in the simpler models. In contrast, none of the parametric models adequately fit the SAT data. The nonparametric model MFS provided a good fit to both the ASVAB and SAT data.

Outside Funding:
Funds for this project are provided by ONT Code 222.

TITLE: Dealing with Uncertainty in Item-Response Theory

PRINCIPAL INVESTIGATOR: Robert J. Mislevy
Educational Testing Service
(609) 734-1271

R&T PROJECT CODE: 4421552

CONTRACT NO: N0001488K0304

CURRENT END DATE: 30 APR 1990

Objective:

Theory and approximations will be developed for a Bayesian approach to model-based test theory, including techniques to obtain marginal distributions of item and person parameters. The framework will be extended to collateral information about persons and tasks, to data gathered in complex population sampling designs, and to test theory models based on cognitive concepts such as knowledge structures and strategy choice.

Approach:

A model-based test theoretic approach in the extended sense described above will be developed within the paradigm of Bayesian inference. Because conjugate priors are not available for IRT and other nonlinear test theory models , investigators will explore approximations including those proposed by Lindley, Rubin, Lewis, and others. The techniques will be illustrated with a variety of applied testing problems.

Progress:

A recent paper examined the use of collateral information on examinees in calibration studies to improve precision of item-parameter estimates. In all cases examined expected precision improvements were obtained. Additionally, in certain circumstances item-parameter estimators were shown to be biased unless collateral information is used.

Report:

Mislevy, R.J. & Sheehan, K.M. (1989) The role of collateral information about examinees in item parameter estimation. Psychometrika, 54, 661-679.

TITLE: Discrete-State Item-Response Models

PRINCIPAL INVESTIGATOR: James A. Paulson
Portland State University
Department of Psychology
(503) 464-3923

R&T PROJECT CODE: 4421550

CONTRACT NO: N0001487K0280

CURRENT END DATE: 30 APR 1990

Objective:
This work is examining new approaches for estimating and validating latent-class models. In previous work the investigator made effective use of the EM algorithm to estimate these models in unconstrained and in a variety of constrained situations. In this work, he is developing a framework for incorporating a monotonicity constraint when appropriate.

Approach:
(a) A test statistic for monotonicity is being developed, and its sampling distribution is being studied. (b) Alternatives to monotonicity are being explored for those situations in which it fails. One approach under study would add additional states to the model. Partially-ordered hierarchical models are also being examined. (c) Links between these discrete-state models and widely studied continuous-state models are being examined. In particular, this approach is being compared with the Bock and Aitkin approach.

Progress:
In general the set of optimal statistics for classifying examinees into latent classes is a set of linear formula scores, one for each latent class. However, if certain homogeneity conditions hold, the optimal statistics are unweighted sums of item scores. Recent work examined the cost of using the simpler statistics when these homogeneity conditions are violated.

TITLE: Multidimensional Item Response Theory Applied to Practical Testing Problems

PRINCIPAL INVESTIGATOR: Mark D. Reckase
American College Testing Program
Test Development Division
(319) 337-1000

R&T PROJECT CODE: 4421556

CONTRACT NO: N0001489J1908

CURRENT END DATE: 30 APR 1992

Objective:
Develop a practical methodology for analyzing test items that require more than one cognitive ability to achieve a correct response. Issues under study include: (a) estimating item parameters, (b) linking the scales of item parameter estimates from various analyses, (c) equating scales of vector ability parameter estimates and of composites of the elements of the ability vectors, (d) technical specifications for tests that assess multiple abilities, and (e) multidimensional adaptive testing.

Approach:
(a) Estimates of standard errors and statistical bias will be used to determine the optimal characteristics of samples used to obtain item parameter estimates. (b) Marginal maximum likelihood procedures will be evaluated for parameter estimation. (c) The Stocking and Lord procedure will be considered as a model for linking the scales of parameter. (d) Equating methodologies will be evaluated with empirical studies on ACT assessment data.

Progress:
(a) Methods have been determined to gauge the parallelism of tests that assess multiple cognitive dimensions. (b) New procedures have been developed to assess the reliability of tests measuring multiple dimensions.

Report:
Reckase, M.D. (1990) Adaptive testing: The Evolution of a Good Idea. Education Measurement Issues and Practice, 8, 11-16.

TITLE: Further Advancement of Latent Trait Theory and Challenge to the Multiphase Response

PRINCIPAL INVESTIGATOR: Fumiko Samejima
The University of Tennessee
Department of Psychology
(615) 974-6846

R&T PROJECT CODE: 4421549

CONTRACT NO: N0001490J1456

CURRENT END DATE: 31 DEC 1992

Objective:
The objective of this work is to extend the theoretical foundations of latent-trait theory. This includes: (a) improvements to modelling techniques, (b) the development of a framework for studying the validity of items and tests as a function of ability, (c) the development of efficient multidimensional modelling techniques, and (d) the extension of latent-trait theory to modelling the details of performance on tasks involving sequences of behavior.

Approach:
(a) The PI's Differential Weight Procedure will be refined and tested. (b) The usefulness of approximations derived from results for multidimensional models of continuous responses will be examined. And, (c) a variety of ways to conceptualize an item's (and a test's) local validity will be examined.

Progress:
A new approach for modelling the operating characteristics of discrete responses to test items has been developed (i.e., the differential-weight procedure). Initial indications are that it is a substantial improvement over the familiar simple-sum procedure when the response functions are steep and the data are sparse.

Report:
Samejima, F. (1990) Content based observation of informative distractors and efficiency of ability estimation. (Tech Rep 90-1), Knoxville, TN: University of Tennessee.

TITLE: Foundations of Multidimensional Item-response Theory.

PRINCIPAL INVESTIGATOR: William F. Stout
University of Illinois
Department of Statistics
(217) 333-6218

R&T PROJECT CODE: 4421548

CONTRACT NO: N0001490J1940

CURRENT END DATE: 14 APR 1993

Objective:
This work is further developing the foundations of item response theory for multidimensional data sets. This includes: (a) exploration of the theoretical relationship between a conditional-association notion of dimensionality and Stout's notion of the essential dimensionality of a data set, (b) exploration of the implications of the Suppes and Zanotti Common Causes Theorem for multidimensional IRT modelling, (c) development of a framework for studying issues of test bias based upon the notion of the essential dimensionality of a test, and (d) exploration of alternative dependence structures for multidimensional modelling.

Approach:
(a) Stout's notion of the essential dimensionality of a data set is being refined and extended, and the relationship between it and Holland's notion of conditional association is being studied. (b) The notion of test bias is being cast within the essential dimensionality framework in order to gauge when group differences are likely to be troublesome. (c) New notions of the reliability of a test are being explored. And, (d) models based upon sequential dependence structures are being examined.

Progress:
Substantial progress has been made on three issues: characterization and assessment of the essential dimensionality of a test, characterization and assessment of test bias, and foundational work on the estimation of ability.

Report:
Stout, W. (1990) A new item response theory modelling approach with applications to unidimensional assessment and ability estimation. Psychometrika, 55.

TITLE: Improved Scoring for Tests and Criteria

PRINCIPAL INVESTIGATOR: James B. Sympson
Navy Personnel Research and Development Center
(619) 553-7610

R&T PROJECT CODE: 4421554

CONTRACT NO:

CURRENT END DATE: 30 SEP 1990

Objective:
Develop new item-selection and performance-modelling techniques which have the potential for increasing the reliability and validity of tests and criteria. Although emphasis will be given to modelling multicategory data, attention will also be given to exploiting information in response times.

Approach:
First, Sympson's polyweighting procedures will be compared to number-correct and IRT-based scoring using both simulation and Navy data. Second, Sympson's Model 8 will be adapted for use in modelling dichotomous (right-wrong) item responses. Third, a new procedure for gauging IRT-model goodness-of-fit will be developed. Fourth, analyses will be conducted to determine whether test scores that are functions of both accuracy of response and speed of response can increase test reliability and validity. Finally, work aimed at improving the scaling of criterion measures will explore the viability of applying polychotomous scoring to these measures.

Progress:
(a) An empirical comparison of polyweighting, number-correct scoring, and dichotomous IRT scoring has been completed. (b) A portable computer program for linear polychotomous item analysis was developed. (c) A portable computer program for fitting a 5-parameter dichotomous IRT model was developed. (d) A new IRT-model goodness-of-fit procedure was developed and applied to Navy data. (e) A new instrument for collecting polychotomous job-performance data for the Navy EM rating was developed. (f) A comprehensive literature review was undertaken and is nearing completion.

Report:
Sympson, J. B. (1990) Improving Scoring for Personnel Tests. Proceedings of the International Personnel Management Association Assessment Council (IPMAAC) 1990 Conference on Personnel Assessment.

TITLE: Advancement of the Theory of IRT-based Error Diagnostic Testing.

PRINCIPAL INVESTIGATOR: Kikumi K. Tatsuoka
Educational Testing Service
Model-based Measurement Research Group
(609) 734-1045

R&T PROJECT CODE: 4421559

CONTRACT NO: N0001490J1307

CURRENT END DATE: 30 JUN 1992

Objective:
The objective of this work is to extend the Rule Space approach to diagnostic testing in three important areas: (a) a coherent approach to test item construction/ selection/ evaluation will be developed; (b) a more powerful approach to classifying response patterns will be sought; and (c) techniques for modelling "bug migrations" will be explored.

Approach:
(a) The investigators' approach to the item construction/selection issue involves constructing stochastic models of item subtask performance. Their initial approach views item subtasks as know entities. (b) The focus of attention for increasing the power of classification procedures will be on methods which avoid the multivariate Normality assumption employed in discriminant analysis. Methods such as kernel density estimation and the k-nearest-neighbor method will be explored initially. (c) Work on identifying and modelling "bug migrations" will employ combinatorial analyses of response patterns to detect phase changes.

Progress:
(a) A detailed empirical validation study of the rule-space diagnoses in the fraction-arithmetic domain has been completed. Results indicated that rule-space is an effective tool for routing students to remedial instruction. (b) Results of a second study confirmed the robustness of the rule-space classification scheme to violations of the normality assumption.

Report:
Tatsouka, K.K. (1990) Toward an integration of item response theory and cognitive error diagnosis. In Fredriksen, N. et al. (eds) Diagnostic monitoring of skill and knowledge acquisition. Erlbaum.

TITLE: The Implications of Multidimensionality for Item-Response-Theory Applications

PRINCIPAL INVESTIGATOR: Ming-mei Wang
Educational Testing Service
Research Department
(609) 734-1933

R&T PROJECT CODE: 4421561

CONTRACT NO: N0001490J1970

CURRENT END DATE: 14 APR 1992

Objective:
This work has three main objectives: (a) to understand the relationships between estimated multidimensional models and their estimated unidimensional counterparts; (b) to develop methods for empirically assessing the "strength" of multidimensionality in terms of the conditional dependence among items; and (c) to provide a framework for evaluating the effectiveness of unidimensional versus multidimensional modeling in testing applications.

Approach:
(a) A detailed analysis of the model-based explanations for differential item functioning is being conducted with emphasis on the issue of multidimensionality. (b) The effects of multidimensionality on test equating and the interpretability of equated scores are being addressed in terms of characteristics of equating samples. (c) The relationship between characteristics of a multidimensional item pool and the efficiency of unidimensional adaptive testing is being studied. And, (d) an effective item selection strategy is being devised with the aid of multidimensional item response functions.

Progress:
An analytical framework based on the linearity of item logit scores for the usual compensatory logistic item response model was defined. Within this framework, algebraic relationships between unidimensional estimates and true multidimensional parameters were derived. The implications of this relationship on various testing applications are discussed.

Report:
Wong, M.M. (1990). Unidimensional versus Multidimensional Modeling for Test Development. (Tech. Rep.) Iowa City, IA: University of Iowa.

TITLE: Bayesian Inference in Factor Analysis

PRINCIPAL INVESTIGATOR: George Y. Wong
Sloan Kettering Institute

R&T PROJECT CODE: 4421536

CONTRACT NO: N0001485K0485

CURRENT END DATE: 31 AUG 1990

Objective:
This effort is extending previous work on Bayesian approaches to factor analysis. A framework for characterizing the moments of the marginal posterior distributions of the factor loadings, factor scores, and uniqueness variances is being developed; expressions for estimation errors are being derived and compared with those obtained under maximum-likelihood and Bayes-joint-modal approaches; and the sensitivity of the marginal moments to variations in the prior distributions is being examined. In addition these marginal procedures are being extended to the study of oblique factor models, of models with a priori zero factor loadings, and of simultaneous factor models.

Approach:
This work is employing a combination of theoretical development of the techniques and Monte Carlo simulation to check the performance of the techniques under controlled conditions. A central element of this research involves approximating the marginal moments of the posterior distributions of factor loadings, factor scores, and uniqueness variances. Techniques based upon an extension of the so-called Tiao-Zellner expansion and refinements of the EM algorithm are being explored.

Progress:
An unsettled question in Bayesian normal linear analysis concerns the form of the marginal distribution of parameters which are jointly poly-t. In a recent paper investigators established that in general these marginal distributions are not poly-t. Sufficient conditions for these marginals to be poly-t were provided and a variety of special cases were considered.

Report:
Wong, G.Y. (1990) Characterizing marginal distributions of a poly-t vector with applications to Bayesian linear modelling. (Biometric Laboratory Report) New York, NY: Memorial Sloan-Kettering Cancer Research Center.

PERCEPTUAL SCIENCE

VISION AND VISUAL ATTENTION

TITLE: Studies of Contour and Surface Segmentation in Monkey Striate Cortex using Voltage Sensitive Dyes

PRINCIPAL INVESTIGATOR: Gary G. Blasdel
Harvard College
Department of Neurobiology
(617) 732-1214

R&T PROJECT CODE: 442g005

CONTRACT NO: N0001489J1953

CURRENT END DATE: 07 MAY 1992

Objective:
The objectives of this research are to: (1) determine the extent to which striate cortex neurons are sensitive to the distinction between contour edges and surface edges; (2) to explore the anatomical and topological organization of striate cortex cell groups categorized on this basis.

Approach:
Extracellular single unit recordings in monkey striate cortex will be used to determine response selectivity to surface and contour edges in response to a variety of visual stimuli. Optical imaging with voltage-sensitive dyes will be used to map patterns of cortical activity in response to visual stimuli optimized for distinguishing contour-edge and surface-edge sensitive regions.

Progress:
Single unit recordings from the macaque primary visual cortex now confirm the principal investigator's view that neurons within cytochrome oxydase blobs respond most effectively to surface features of objects, such as color or texture, while cells outside these blobs (and within orientation columns) are optimally responsive to object edges. This pattern of results provides important clues regarding how the visual system distinguishes objects from background and identifies object properties.

Report:
Blasdel, G.G. (1989) Visualization of neuronal activity in monkey striate cortex. Annual Review of Physiology, 51, 561-581.

TITLE: Neurophysiological Implementation of a Scheme for Visual Selective Attention

PRINCIPAL INVESTIGATOR: John Duncan
Cambridge, England
Applied Psychology Unit

R&T PROJECT CODE: 4424240

CONTRACT NO: N0001490MP24005

CURRENT END DATE: 01 OCT 1990

Objective:
The aim of this collaborative research effort is to examine three questions fundamental to our understanding of the neural basis of visual selective attention: (1) What is the brain locus and functional character of template, or preexisting internal description, that guides the momentary focus of visual attention? (2) How do simultaneous inputs interact competitively to produce a single attentional focus, and (3) How does attention modulate activity in different extrastriate areas in order to enable the preferential processing input from multidimensional (color, form, motion) stimulus objects?

Approach:
Single unit recording techniques will be used to examine patterns of activity in a variety of extrastriate cortical regions (V2, V3, V4) during attention demanding tasks in which alert behaving monkeys are presented with multiple simultaneous visual stimuli, only one of which they are trained to attend on any given trial.

Progress:
Cells in area V4 of the extrastriate cortex which code a sample stimulus (e.g., a red circle) form two distinct subpopulations: those that become relatively more active during match-to-sample tasks involving the sample stimuli they code and those that become less active. This finding, which runs contrary to what would be predicted from prior results, is interpreted tentatively in terms of the effects of attentional selectivity on the color tuning of cells.

TITLE: Visual Perception of Depth-from- Occlusion: A Neural Network Model

PRINCIPAL INVESTIGATOR: Leif H. Finkel
University of Pennsylvania
Department of Bioengineering
(215) 898-1483

R&T PROJECT CODE: 4424255

CONTRACT NO: N0001490J1864

CURRENT END DATE:

Objective:
The objective is to uncover how the visual system perceives depth from occlusion--the situation in which one object partially blocks to view of a more distant object--and to incorporate this understanding into the design of a neural network model capable of emulating the depth perception performance of biological visual systems.

Approach:
The research approach consists of (1) developing and implementing a model of occlusion discrimination in a neural network system, (2) using this model to investigate mechanisms of integration of depth information, and (3) writing a computer simulation program to carry out a formal evaluation of the computability of the neural network model.

Progress:
This grant is new in FY90.

TITLE: Core Support for the Committee on Vision

PRINCIPAL INVESTIGATOR: Pamela Flattau
National Academy of Sciences
(202) 334-2565

R&T PROJECT CODE: 4426125

CONTRACT NO: N0001487K0345

CURRENT END DATE: 28 FEB 1990

Objective:
Provide information on current and anticipated problems relevant to Navy and other federal agencies in the areas of vision, visual standards, and hazards to vision.

Approach:
Working groups will be formed to address specific issues identified by a sponsor. Each group will be made up of leading experts in scientific fields relevant and specific to the problem at hand, and will produce a document responsive to problem solution.

Progress:
The Working Group on Wraparound Visual Displays undertook initial studies of special problems in display design arising from teleoperated robotic vehicles. The Working Group on Contact Lenses prepared a technical report on use of contact lenses in the extreme conditions of the military aerospace environment. The Working Group on Myopia Prevalence and Progression completed its work and submitted its final report; the report summarizes demographic variables that must be evaluated in comparing older myopia prevalence data with current data and contains an analysis on myopia prevalence and progression.

TITLE:	Computational and Psychophysical Study of Human Vision Using Neural Networks
PRINCIPAL INVESTIGATOR:	Donald A. Glaser University of California, Berkeley Department of Molecular and Cell Biology (415) 642-7231
R&T PROJECT CODE:	4424243
CONTRACT NO:	N0001490J1251
CURRENT END DATE:	30 SEP 1992

Objective:
The objective is to carry out empirical investigations to evaluate and modify current computational models of processes by which information about the physical properties of the external environment is extracted by the human visual system. Of primary interest are the investigation of detection and identification of moving objects in noisy environments, the role of global (non-local) processes in the perception of three dimensionality, the perception of flow patterns and textures, and the processes by which detectable lines and their intersections within images are labeled or assigned roles in image interpretation.

Approach:
The approach is interdisciplinary, combining empirical investigation at the level of visual psychophysics and computational modeling. Preliminary theoretical developments are used to guide the specification of empirical questions, and the resultant findings are used to evaluate and extend theoretical formulation.

Progress:
Depth perception for simple dot and line patterns in the center of the field of view was found to be grossly altered by other dots and lines almost anywhere in the whole field of view. Perception of speed in central display patterns likewise was found to be altered by other dots blinking on and off in the same scene. These results impose important constraints on the kinds of neural nets appropriate for modeling human vision. The visual system appears to compute some sort of overall scene average or reference structure as part of producing a conscious local perception.

TITLE: Using Time-to-Collision to Recover 3-D Motion for Navigation and Manipulation

PRINCIPAL INVESTIGATOR: Ellen Hildreth
Massachusetts Institute of Technology
Department of Brain and Cognitive Science
(617) 253-5819

R&T PROJECT CODE: 400x053

CONTRACT NO: N0001488K0607

CURRENT END DATE: 24 SEP 1991

Objective:
To establish the computational and psychophysical bases for design of networks that have the capacity to compute quickly and accurately the structure and relative motions of environmental objects with which an artificial system may physically interact during the course of navigation and object manipulation.

Approach:
Estimates of the time-to-collision with an approaching surface will be used to investigate the recovery of 3-D trajectory of moving targets. The psychophysical findings will be employed as the basis for design of computational models of visually-guided navigation and object manipulation.

Progress:
An algorithm has been developed that reconstructs a 3-D trajectory from simple measurements of the position, velocity and rate of expansion of image features, and then derives global parameters for the trajectory (that is, initial 3-D position of the object and velocities through space).

Report:
Hildreth, E. (1990) Computational studies of visual motion analysis. In M. Imbert (Ed.) Models of Visual Perception: From Natural to Artificial, Oxford University Press.

TITLE: Workshop on Computational and Biological Models of Visual Processing

PRINCIPAL INVESTIGATOR: Ellen C. Hildreth
Massachusetts Institute of Technology
Department of Brain & Cognitive Science
(617) 253-5819

R&T PROJECT CODE: 4424244

CONTRACT NO: N0001490J1418

CURRENT END DATE: 30 NOV 1990

Objective:
The objectives are to identify the most pressing problems in computational vision for future research, to explore new theoretical and methodological approaches for addressing these problems, and to foster possible future collaborations between U.S. and European vision scientists.

Approach:
The conference will be held over three days. Each participant will give a 30-minute presentation outlining both their own research and their view of the pressing research problems in the field. Extensive discussion periods are scheduled following each group of presentations. Evenings will be devoted to less formal discussions of issues and approaches. The workshop proceedings will be published as a book.

TITLE: Electrophysiological Studies of Visual Selective Attention and Resource Allocation

PRINCIPAL INVESTIGATOR: Steven A. Hillyard
University of California
Department of Neurosciences
(619) 534-2385

R&T PROJECT CODE: 4426556

CONTRACT NO: N0001489J1806

CURRENT END DATE: 31 MAY 1992

Objective:
To clarify mechanisms of visual-spatial selective attention in humans, both at the level of perceptual processing and at the level of the underlying brain physiology. The focus will be on the effectiveness of different advance cueing procedures for orienting attention to regions of a visual display.

Approach:
The indices of attentional orienting to be studied are facilitation of reaction times and enhanced event-related potentials (ERPs) to stimuli at attended locations. The proposed methods will eliminate confounds that have clouded the interpretation of previous studies.

Progress:
Findings from earlier studies have been replicated, showing that when attention is directed to one visual field while bilateral stimuli are presented, the stimulus falling upon the attented location elicits an enlarged P1 wave over the occipital scalp contralateral to the stimulus.

Report:
Luck, S.J., Hillyard, S.A., Manqun, G.R., and Gazzaniga, M.S. (1989) Independent hemispere attentional systems mediate visual search in split-brain patients. Nature, 342, 543-545.

TITLE: Workshop on Computational Approaches To Neuroscience

PRINCIPAL INVESTIGATOR: Susan Hockfield
Cold Springs Harbor Laboratory
Neurobiology Program
(203) 785-5944

R&T PROJECT CODE: 4424220

CONTRACT NO: N0001488J1165

CURRENT END DATE: 31 DEC 1990

Objective:

Objectives are: (1) to conduct interdisciplinary workshops on computational approaches to neuroscience; (2) to identify and test advanced computational models of ocular motor control, vision and sensory guided motor control; and (3) to promote interdisciplinary collaboration and training among scientists working in the life sciences and the physical sciences on research projects in the rapidly growing field of computational neuroscience.

Approach:

Senior scientists, graduate students and post doctoral fellows in biology, psychology, computer science, engineering and physics will participate in summer workshops. The workshops will consist of tutorials and hands-on laboratory sessions during which advanced computational models will be described, implemented and tested in computer simulations. Model results will be compared with actual data sets and the merits of the models will be evaluated.

Progress:

A workshop on computational models of visual processing was organized by T. Movshon and M. Landy and held at Cold Spring Harbor Laboratory 26-30 June, 1989. Thirty scientists participated and received hands-on experience in computer modeling of neuroscience data on early visual processing.

Report:

Landy, M. and Movshon, T. (Eds.)(1989)Computational Models of Visual Processing, MIT Press.

TITLE: Formal and Psychophysical Investigations of Vision: Image Motion and Occluding Contours

PRINCIPAL INVESTIGATOR: Donald D. Hoffman
University of California, Irvine
Department of Cognitive Sciences
(714) 856-6795

R&T PROJECT CODE: 4424219

CONTRACT NO: N0001488K0354

CURRENT END DATE: 31 JUL 1991

Objective:
The objective of the proposed research is to develop and to evaluate both empirically and computationally a formal theory of the mechanisms by which object shape can be inferred from motion and contour occlusion. An additional objective is to implement this theory in neurally plausible computer algorithms.

Approach:
The proposed investigation will consist of three integrated thrusts: (1) the development of formal theories of shape-from-motion and shape from occluding contours, (2) the testing of these theories by psychophysical experiments, and (3) the implementation of these theories in neurally plausible computer algorithms.

Progress:
An extensive series of psychophysical experiments have been carried out to evaluate a set of formal rules postulated by the principal investigators as governing how 3D shapes might be divided into primitive parts in the human visual system in order to derive representations suitable for recognition of objects. The experimental results are highly supportive of the principal investigator's analysis.

Report:
Bennett, B., Hoffman, D. & Prakash, C. (1989) Observer Mechanics. New York: Academic Press.

1498 TITLE: Analog Neuronal Networks for Early Vision

PRINCIPAL INVESTIGATOR: Christof Koch
California Institute of Technology
Computation and Neural Systems Program
(818) 356-6855

R&T PROJECT CODE: 400x038

CONTRACT NUMBER: N0001487K0519

CURRENT END DATE: 15 OCT 1990

Objective:
Objective is to develop theoretical models of computation for early visual processes toward analog VLSI chips for use in robotic vision systems.

Approach:
Approach is to simulate analog algorithms for vision on a hypercube computer in two stages; first as independent, then as integrated, processes. Explore design possibilities for silicon implementation.

Progress:
A 20x20 pixel chip was designed with circuitry that performs surface segmentation and smoothing of visual input. The analog VLSI circuit implements a non-linear resistive network with "fuses" that detect discontinuities and limit the smoothing operation. A variety of resistive networks find edges, compute depth and optical flow in the presence of discontinuities. These circuits are sufficiently robust to allow edge following and tracking when mounted on toy cars in laboratory environments.

Report:
Harris, J.G., Koch, C., and Luo, J. (1990) A two-dimensional analog VLSI circuit for detecting discontinuities in early vision, Science, 248, 1209-1211.

TITLE: Physiology of Selective Attention

PRINCIPAL INVESTIGATOR: Harold E. Pashler
University of California, San Diego
Psychology Department
(619) 534-3974

R&T PROJECT CODE: 4424212

CONTRACT NO: N0001488K0281

CURRENT END DATE: 31 JAN 1991

Objective:
The objectives are to better characterize the mechanisms whereby primates selectively attend to stimuli that are relevant, while ignoring irrelevant stimuli.

Approach:
Both human subjects and macaque monkeys will be studied under similar task conditions. Psychophysical measures will be obtained from both subject types, and carefully controlled physiological measures of attention-related neural activity in cortical and subcortical structures will be obtained in the monkeys studied.

Progress:
Recent work has studied how boundaries detected in different "feature maps" are joined up to allow object recognition to occur. One possibility is that boundaries recognized separately in different dimensions can separately access long term memory for shape recognition. The alternative is that the boundaries detected in different dimensions are merged into a "master boundary map" prior to shape recognition. Experiments to date favor the latter possibility.

Report:
Pashler, H. (In Press). Visual selective attention and the two-component theory of divided attention. Journal of Experimental Psychology: General.

TITLE: Visual Integration and Recognition

PRINCIPAL INVESTIGATOR: Tomaso A. Poggio
Massachusetts Institute of Technology
Center for Biological Information Processing
(617) 253-5230

R&T PROJECT CODE: 442g002

CONTRACT NO: N0001488K0164

CURRENT END DATE: 31 DEC 1990

Objective:
Objective is to specify biologically plausible implementation models for visual integration and recognition.

Approach:
Approach is interdisciplinary collaboration in computation, psychophysics and physiology. Theoretical and computational studies will examine the information processing tasks involved in visual integration and recognition. Algorithms will be developed and tested on a parallel supercomputer. Computational work will guide design of experiments in human and monkey psychophysics. The physiology will examine the neural implementation of integration and recognition tasks in primate cortex.

Progress:
A new parallel algorithm that computes optical flow in near real-time for natural images was developed and implemented on a Connection Machine supercomputer. Optical flow is a flow of apparent motion that occurs on the retina as the observer moves about in a 3-D world. The algorithm is in three stages: the first stage matches features in successive frames, the second is a local summation, the third computes velocities for each xy position of the image representation. The algorithm is consistent with several perceptual effects (barber pole and motion-capture illusions), and is a plausible model in terms of primate cortical physiology.

Report:
Bulthoff, H, Little, J, and Poggio, T. (1989) A parallel algorithm for real time computation of optical flow, Nature, 337: 549-553.
Poggio, T. and Edelman, S. (1990) A network that learns to recognize three-dimensional objects. Nature, 343: 263-266.
Poggio, T. and Girosi, F. (1990) Regularization algorithms for learning that are equivalent to multilayer networks. Science, 247: 978-982.

TITLE: Functions of Identified Neural Areas in Selective Attention

PRINCIPAL INVESTIGATOR: Michael I. Posner
University of Oregon
Department of Psychology
(503) 686-3186

R&T PROJECT CODE: 4424233

CONTRACT NO: N0001489J3013

CURRENT END DATE: 31 MAY 1992

Objective:
The objective is to understand general principles underlying the regulation of data processing in the brain by the attentional system. Two major ideas emerging from the principal investigator's earlier work are to be evaluated: (1) the attentional system is functionally and anatomically distinct from the data collection and execution systems on which it operates; and (2) the attentional system is defined as a set of interconnected posterior and anterior brain areas that taken together select information for focal processing.

Approach:
The approach entails the use of both behavioral (reaction time) and neuroscientific (evoked potential) techniques to investigate the relation between attention and data collection systems in the human brain. Evoked potential measures will be used to track patterns of attentional activation progressing from anterior (midline anterior cingulate to supplementary motor area) to posterior (parietal and temporal) attentional structures following the cuing of likely target locations.

Progress:
Experimental evidence from both humans and animals has established the existence of two distinct attentional systems in the primate brain. The posterior system, involving the posterior parietal cortex, the midbrain, and the pulvinar, is involved in the covert orienting of attention toward visual locations. The anterior system , involving the anterior cingulate, is involved in the detection and classification of targets. The most recent findings are that the above relationship applies to visual search tasks as well as to simpler non-search tasks. These findings come from PET studies, experiments with brain-damaged subjects, and studies with normal subjects using norepinephrine antagonists.

Report:
Posner, M.I., Peterson, S.E., Fox, P.T., & Raichle, M.E. (1988) Localization of cognitive functions in the human brain. Science, 240, 1627-1631.

TITLE: A Rodent Model to Identify Brain Structures Involved in the Process of Stimulus Recognition

PRINCIPAL INVESTIGATOR: Lawrence A. Rothblat
George Washington University
Psychology Department
(202) 994-6809

R&T PROJECT CODE: 4424210

CONTRACT NO: N0001488K0227

CURRENT END DATE: 31 JAN 1991

Objective:
The objective is to develop a rodent model system for investigation of the role of limbic system structures, including the hippocampus, the amygdala, and the rhinal cortical structures, in the memory and recognition of visual objects and their spatial locations.

Approach:
Lesion and tracer techniques will be used to examine the role in stimulus recognition of a variety of limbic system structures, including the hippocampus, amygdala, and rhinal cortex. The effects of controlled lesions will be assessed behaviorally and verified histologically.

Progress:
Animals with hippocampal lesions were found to be severely impaired when learning several pairs of object discriminations concurrently. Hippocampal lesions also impaired performance on a spatial memory test. In newborn hamsters, with lesions of visual cortex, superior colliculus and inferior colliculus, which induced retinal projection to auditory centers, visual pattern stimuli were discriminated at the 90% level.

TITLE: Brain Communication Theory, Attention and Automaticity

PRINCIPAL INVESTIGATOR: Walter Schneider
University of Pittsburgh
Learning Research and Development Center
(412) 624-7061

R&T PROJECT CODE: 4424901

CONTRACT NO: N0001487K0397

CURRENT END DATE: 31 MAY 1990

Objective:
The objective is to carry out behavioral studies with humans and neurophysiological research with monkeys to assess the nature and anatomical locus of the brain mechanisms underlying visual attention, and the functional changes in these mechanisms that occur during learning.

Approach:
Data will be taken from human subjects engaged in a variety of tasks that require visual attention. The task parameters found to be effective within humans in modifying attentional function through experience will be employed with monkeys. Single unit recordings of neural activity in several visual information processing structures (V4, IT, PULVINAR, FRONTAL EYE FIELDS) will be taken from the monkeys, while engaged in the attentional tasks. These data will be used to assess where attentional effects occur in the visual system and how these effects change with learning.

Progress:
An attentional movement paradigm that provides time stable distribution data with small numbers of observations. Evidence from this paradigm indicates that attention moves discretely rather than in analogue fashion across visual space. A model of information processing, called the Controlled Automatic Processing (CAP) model has been evaluated in several studies. Several implications of the model have been verified. In neurophysiological work, two brain structures believed to operate in the attentional circuit were chemically deactivated. Both structures, the Lateral Pulvinar and the Superior Colliculus, were shown to be critical in the effective movement of attention.

Report:
Schneider, W., & Detweiler, M. (1988) The role of practice in dual-task performance: Toward workload modeling in a connectionist/ control architecture. Human Factors, 30, 539-566.

TITLE: Control of the Minds Eye: The Dynamics of the Distribution of Visual Attention

PRINCIPAL INVESTIGATOR: Arthur F. Kramer
University of Illinois
Department of Psychology
(217) 333-9532

R&T PROJECT CODE: 4424228

CONTRACT NO: N0001489J1493

CURRENT END DATE: 31 DEC 1991

Objective:
The objective is to develop an empirically based model of visual selective attention which describes, at multiple levels of representation, the control of the allocation of attention in visual space.

Approach:
Interference in response speed and accuracy produced by visual distractors will be used as an index to investigate a number of critical issues related to the computational properties of visual-spatial attention. Included among these issues are the following: (1) the minimal visual angle or focus of attention in which all events must be processed; (2) the information processing level(s) at which noise stimuli of various types operate to degrade performance; and (3) the effects of training on the ability of performers to adaptively filter unwanted components of a visual scene.

Progress:
Three different models of attentional control have been compared experimentally: (1) space-based models (e.g., of Eriksen), (2) object-based models (e.g., of Duncan, Kahneman, Treisman, and Kramer), and (3) a hybrid model (Kramer) which bases control both on space and object specification. Two experiments have been completed, and the results provide strong support of the hybrid model over the space- and object-based models. Two different experiments examined the information-processing consequences of training on consistent S-R mapping tasks. The results support the conclusion that training both strengthens relevant mappings and inhibits irrelevant mappings.

Report:
Strayer, D.L. and Kramer, A.F. (In Press) Attentional requirements of automatic and controlled processing. Journal of Experimental Psychology: Learning, Memory & Cognition.

TITLE: Investigation of Spread of Attention in the Visual Field

PRINCIPAL INVESTIGATOR: David La Berge
University of California, Irvine
Department of Cognitive Sciences
(714) 856-6802

R&T PROJECT CODE: 4424208

CONTRACT NO: N0001490J1447

CURRENT END DATE: 31 JAN 1993

Objective:
The objective is to test and elaborate the principal investigator's gradient theory of visual-spatial attention. Evaluation of the theory will be based on empirical research and computer simulation.

Approach:
An extensive series of experiments will be carried out to analyze the 'width of attentional focus' effect, on which the principal investigator's theory of attention is based, to explore methods to produce and sustain a focus of a given size, and to determine ways in which the focus-width effect can be exploited to optimize human performance in tasks involving object recognition.

Progress:
An extensive series of behavioral and PET experiments have been completed during the past two years of ONR-supported work, culminating in a major empirical/theoretical piece (referenced below) which represents a major advance in our understanding of the computational role and functional contributions of visual-spatial attention in the recognition of familiar objects such as letters, digits, and words. The principal investigator's computational model of attention is closely linked to the current physiological and behavioral data on attentional selectivity, and is proving to be a powerful tool in predicting attentional effects under a wide variety of viewing conditions.

Report:
LaBerge, D. and Brown, V.(1989) Theory of attentional operations in shape identification. Psychological Review, 96, 101-124.

TITLE: Processing Information in the Cerebral Cortex

PRINCIPAL INVESTIGATOR: John H. Maunsell
University of Rochester
Strong School of Medicine and Dentistry
(716) 275-2076

R&T PROJECT CODE: 4424242

CONTRACT NO: N0001490J1070

CURRENT END DATE: 30 SEP 1992

Objective:
The objectives of this work are: (1) to determine if neurons that are most active when the animal searches for a specific visual stimulus also respond selectively during search for a specific haptic stimulus; (2) to determine whether individual neurons can signal task-specific information for more than one task; (3) to determine effects of training on task-specific responses of cortical neurons.

Approach:
Recordings of single unit activity in cortical area V4 of alert macaque monkeys will be obtained during match-to sample-tasks in which the sample and the choice are either visual or tactile stimuli.

Progress:
Single unit recordings of neuronal activity in area V4 of alert macaque monkeys during visual match-to-sample tasks has provided evidence that neurons in V4 respond selectively to the stimulus that is being searched for, independent of the visual stimulus present. The proportion of sampled neurons that are selective increases with time during the period of testing.

Report:
J. Maunsell et al. (1989) Representation of extraretinal information in monkey visual cortex. D. Lam (ed), Proc. of Retinal Research Foundation Symposium, Vol 2.

TITLE: The Role of Attention in Visual Processing

PRINCIPAL INVESTIGATOR: Gordon L. Shulman
Washington University
Department of Neurology
(314) 362-7170

R&T PROJECT CODE: 4424229

CONTRACT NO: N0001489J1426

CURRENT END DATE: 31 MAR 1992

Objective:
The objective is identify the anatomical locus of a variety of attentional effects in vision which have not been investigated on a systematic basis. Both spatial and non-spatial attentional effects will be studied, using sensory adaptation as the vehicle for identifying attentional influences.

Approach:
Sensory adaptation and sensory learning effects will be investigated in the presence and absence of focused attention. Since the anatomical locus of the adaptation effects studied have been established, it is possible by this means to isolate the anatomical locus of attentional effects in the visual information processing sequence.

Progress:
Consistent with the theoretical analysis initiating this project, the principal investigator has found that the degree of sensory adaptation to rotation in depth is dependent on whether the stimulus object is attended. This indicates that the mechanisms adapted in sensory adaptation experiments are also capable of being attentionally influenced, and reveals new insights into the computational role of attentional selectivity in vision.

Report:
Corbetta, M., Miezin, F.M., Dobmeyer, S., Shulman, G.L. and Peterson, S.E. (1990) Attentional modulation of neural processing of shape, color, and velocity in humans. Science. 248, 1556-1559.

TITLE: Visual Attention and Short Term Memory

PRINCIPAL INVESTIGATOR: George Sperling
New York University
Psychology
(212) 998-7868

R&T PROJECT CODE: 4424221

CONTRACT NO: N0001488K0569

CURRENT END DATE: 14 JUL 1991

Objective:

The objective of the proposed project is to develop formal quantitative descriptions of the mechanisms by which attentional modulation and control structures determine the perception of visual events, and to incorporate these descriptions into a theoretical treatment of human information processing and the sources of its limitations.

Approach:

The proposed project incorporates both psychophysical and computational analyses to generate the empirical basis for and computational evaluation of a formal theory of the role of attention in the analysis of visual sensory input.

Progress:

A computationally efficient model of human selective attention has been developed and verified experimentally. A neural network implementation of the model has been developed, and is under refinement.

Report:

Sperling, G., Dosher, B.A., Landy, M.S. (1990) How to study the kinetic depth effect experimentally. Journal of Experimental Psychology: Human Perception and Performance, 16, (In Press).

TITLE: Constructing 3D Surface Descriptions

PRINCIPAL INVESTIGATOR: Kent A. Stevens
University of Oregon
Department of Computer Science
(503) 686-4430

R&T PROJECT CODE: 4424245

CONTRACT NO: N0001490J1472

CURRENT END DATE: 31 DEC 1992

Objective:
The objective is to develop a comprehensive theory of 3-D form perception based on the assumption of two independent representation systems for distance information: (a) for absolute distance, indicated by binocular disparity, and (b) for local object-referenced depth relations.

Approach:
Theoretical analysis, computational modeling, and psychophysical experimentation are utilized to determine the nature of surface topographic features, their interactions, and how the perception of 3D form arises in human vision from those features.

Progress:
This grant is new in FY90.

TITLE: Visual Perception and Cognition of Smoothly Curved Surfaces

PRINCIPAL INVESTIGATOR: James T. Todd
Brandeis University
Department of Psychology
(617) 736-3300

R&T PROJECT CODE: 4424241

CONTRACT NO: N0001490F0003

CURRENT END DATE: 30 SEP 1992

Objective:
During the past decade, there have been numerous algorithms proposed in the literature for computing an object's 3D form from a sequence of projected images taken from different perspectives. The objective here is to identify the key assumptions underlying these alternative algorithms and to empirically examine the relative psychophysical validity of these assumptions.

Approach:
The approach is to determine the psychophysical implications of competing models of the process by which 3D form is computed from the 2D image projected to the retinal surface, and to subject these implications to rigorous empirical test.

Progress:
This grant is new in FY90.

Outside Funding:
Funded jointly with AFOSR and NSF.

TITLE: Visual Perception of Features and Objects

PRINCIPAL INVESTIGATOR: Anne Treisman
University of California, Berkeley
Department of Psychology
(415) 642-5292

R&T PROJECT CODE: 4424251

CONTRACT NO:

CURRENT END DATE: 01 SEP 1992

Objective:
To conduct experimental studies on feature analysis, the perception of conjunctive features, the effects of extended practice on visual search, the role of attention, object representation for dynamic images, the maintenance of object identity, the unity or grouping of object features, and memory for visual patterns.

Approach:
Experimental studies examine the nature of the stored representation for specific features, the generality of that process for implicit and explicit memory tasks, and the dependence of perception on instructions during the acquisition of information.

Progress:
This grant is new in FY90.

Outside Funding:
Funded jointly with AFOSR.

TITLE: Neural Models of the Visual Cortex in Information Processing

PRINCIPAL INVESTIGATOR: David C. Van Essen
California Institute of Technology
Biology Division
(818) 356-6823

R&T PROJECT CODE: 4425083

CONTRACT NO: N0001489J1192

CURRENT END DATE: 30 NOV 1991

Objective:
Objective is to determine how information about motion, texture and depth is represented and transformed in early stages of visual processing. Emphasis is on recognition of complex visual forms viewed by task oriented humans and primates.

Approach:
Approach is interdisciplinary and collaborative, combining computational modeling, human psychophysics and primate neurophysiology. Cortical activity in animal experiments will be traced using voltage-sensitive dyes and optical recording techniques.

Progress:
A series of experiments was conducted into the nature of texture and motion processing in visual cortex of macaque monkeys. Single unit recordings from neurons in areas V1 and V2 revealed sensitivity to texture contrast. Cells which were selective for a particular orientation of a line segment showed enhanced response when the surround texture was composed of orthogonally oriented segments. Motion-selective cells in cortical area MT, however, did not respond more vigorously when texture contrast was added to the motion cue.

Report:
Van Essen, DC, DeYoe, EA, Olavarria, JF, Knierim, JJ, Sagi,D, Fox, JM, and Julesz, B. (1989) Neural responses to static and moving texture patterns in visual cortex of the macaque monkey.In: Neural Mechanisms of Visual Perception, Lam, DMK and Gilbert, C. (Eds) Portfolio Publishing, Woodland, TX, pp. 135-153.

PERCEPTUAL SCIENCE

AUDITION

TITLE: Contextual Encoding of Acoustic Transients

PRINCIPAL INVESTIGATOR: Thomas E. Hanna
Naval Submarine Base, New London
Behavioral Sciences Department
(203) 449-2561

R&T PROJECT CODE: 4424207

CONTRACT NO: N0001490WR24003

CURRENT END DATE:

Objective:
To test theories of trace and context encoding in the classification of acoustic transients that arise from either active or passive sound sources.

Approach:
Predictions of classification performance are tested with signals from active and passive sound sources taken from the ASW environment. The relevant information-bearing dimensions within those underwater sounds is extracted and systematically manipulated; operator performance with those sounds is compared with results with the single dimensions of acoustic signals studied in the initial phase of this program. The degree of perceptual encoding for the dimensions is related to sensory processes and the impact of signal context is assessed.

Progress:
Performance on the discrimination of modulation rate was shown to be dependent on the range of those rates and that result suggested that intensity perception is a dominant factor in those judgments. Linear and logarithmic spacing between signals produced strikingly different results in the identification of modulation rate; those results suggest that classificatgion performance is sensitive to spacing differences of the signal features.

Report:
Hanna, T. E. (1989). Preliminary report on classification of transient sonar signals (Tech. Rep.). Groton, CT: Naval Submarine Medical Research Laboratory.

TITLE: Effect of Adaptation on Auditory Discrimination

PRINCIPAL INVESTIGATOR: Kenneth R. Henry
University of California, Davis
Department of Psychology

R&T PROJECT CODE: 4424254

CONTRACT NO: N0001490J1866

CURRENT END DATE: 01 MAY 1991

Objective:
Determine the effects of adaptation on the shapes of the amplitude and phase tuning curves of afferent auditory nerve axons. Survey the extents of those effects, their temporal dependence and dependence on axon characteristic frequency and stimulus parameters. Incorporate these results into computational models of acoustic imaging.

Approach:
Extracellular recording of single auditory afferent axons will be per-formed. Effects of adaptation on the frequency tuning curves of these axons will be evaluated by examining effects of forward masker tones on responses to tone bursts and by shifting the time window over which responses are computed. Phase and amplitude tuning curves will also be determined from cycle histograms and from REVCOR (reverse correlation) analysis.

Progress:
This grant is new in FY90.

TITLE: Auditory Profile Analysis By Parallel Associative Networks

PRINCIPAL INVESTIGATOR: James H. Howard, Jr.
Catholic University of America
Department of Psychology
(202) 635-5748

R&T PROJECT CODE: 4424213

CONTRACT NO: N0001488K0261

CURRENT END DATE: 31 JAN 1991

Objective:
To extend the understanding of the profile analysis model of acoustic discrimination by developing a neural net model of the same acoustic phenomena. To test the neural net model for its discrimination of transient, multitonal signals in order to identify and quantitatively express the algorithms used for the processing of those signals, and to determine the algorithms for the classification of those sounds.

Approach:
Neural net models are developed which discriminate intensity changes in transient, multitonal signals which vary in (a) the number and spatial density of their components; (b) loudness level and its variability; and (c) frequency range. Learning characteristics of the neural network are assessed to quantify the effect of phase, test signal frequency, signal pedestal level, training, irregular frequency spacing, and irregular intensity patterns. Experiments are performed with human listeners to clarify the findings of the network.

Progress:
Experiments have been completed on spectral shape discrimination with uncertain signal frequency using three-layer, feed-forward, parallel networks. Network sensitivity was greater with fixed signal frequency than with varied signal frequency; these results mimic previous findings with human listeners under similar task conditions. The time course for learning intensity discrimination and profile analysis with a neural network was similar to that obtained with human listeners. These results are used to model human auditory phenomena.

Report:
Howard, J.H., Jr., Miller, M. H., & Harpster, J. L. (1990). Context sensitivity in profile analysis by parallel distributed networks. In Proceedings of the Eastern Psychological Association annual meeting.

TITLE: Central Factors in the Classification of Transient Acoustic Signals

PRINCIPAL INVESTIGATOR: Robert A. Lutfi
University of Wisconsin
Waisman Center on Mental Retardation
(608) 262-7734

R&T PROJECT CODE: 4424226

CONTRACT NO: N0001489J1281

CURRENT END DATE: 29 FEB 1992

Objective:
The objective is to determine the role of central factors such as learning, memory, and attention in the classification of complex acoustic signals with random variation similar to that occurring in naturally occurring signals.

Approach:
Psychophysical studies of normal hearing humans will be carried out to determine listeners' ability to integrate information across a wide range of stimulus dimensions, to overcome effects of stimulus uncertainty, and to weight information according to its reliability. Quantitative modeling studies will also be carried out to evaluate hypotheses generated by psychophysical experiments. The methods of signal detection theory will be applied in both experimental and modeling components of this project.

Progress:
Experiments were performed in which listeners hear two sounds which are each four-tone complexes, whose parameters are drawn from two normal distributions differing only in mean. The listener must select the sound originating from the distribution with the highest mean. Results suggest that performance is less dependent on the acoustic parameter along which discrimination is made, than on their information con-tent. There appears to be no advantage to packaging signal information by within-stimulus ordering of the parameter variations, e.g. a pattern of amplitude variations across frequency.

Report:
Lutfi, R. (1989) Informational processing of complex sounds. I: Intensity discrimination. Journal of the Acoustical Society of America, 86, 934-943.

TITLE:	Acoustical Cues for Sound Localization
PRINCIPAL INVESTIGATOR:	John C. Middlebrooks University of Florida Department of Neuroscience (904) 392-3177
R&T PROJECT CODE:	4424227
CONTRACT NO:	N0001489J1427
CURRENT END DATE:	31 DEC 1991

Objective:
The technical objectives of this study are: (1) to determine possible physical cues that may be used by the central nervous system to compute sound source location by making measurements of sound pressure in the human ear canals; (2) to measure in behavioral experiments the accuracy with which humans localize broad- and narrow-band sounds presented at unknown vertical and horizontal locations.

Approach:
Both acoustical and behavioral experiments will be carried out. In acoustical experiments, transient broad- and narrow-band sounds from a movable free field sound source will be presented to human subjects while sound pressure is recorded from miniature microphones inserted into their ear canals. Spatial dependence of sound pressure levels and interaural level differences will be determined from amplitude spectra as a function of location. Interaural envelope delays will be computed from phase spectra. In behavioral experiments, subjects are asked to turn their head toward the apparent location of the source, and head position is monitored with an electromagnetic device attached to the head. The pattern of localization errors is used to determine possible localization strategies.

Progress:
The spatial dependence of sound pressure levels in the human ear canal has been characterized. The spatial dependence of interaural delays of envelopes of high frequency sounds has also been characterized, and an algorithm for computing the directional transfer function of the ear, independent of microphone position, has also been developed.

Report:
J. C. Middlebrooks, J. C. Makous, D. M. Green (1989) Directional sensitivity of sound-pressure levels in the human ear canal. Journal of the Acoustical Society of America 86: 89-108.

TITLE: Principles of Perception in Bat Sonar

PRINCIPAL INVESTIGATOR: James A. Simmons
Brown University
Department of Psychology
(401) 863-1542

R&T PROJECT CODE: 4424202

CONTRACT NO: N0001489J3055

CURRENT END DATE: 30 JUN 1992

Objective:
To determine the fine structure of the image of a sonar target as it is perceived by echolocating bats and to understand the convergence of different representations of that image, i.e., psychophysical, computational, and physiological, that occur during the processes of fusion and formation.

Approach:
Target-ranging experiments employ a jittered-echo procedure to minimize the artifacts introduced by movements of the bat's head and to measure the shape of the acoustic image along an echo-delay or distance axis. Bats are trained in a two-alternative forced-choice procedure to discriminate between a simulated sonar target whose echoes alternate in delay and a simulated target whose echoes have a fixed delay for all transmissions. Echo delay is the acoustic cue used by the bat for the perception of the absolute distance to a target.

Progress:
Experiments on echo-processing and target classification in the brown bat verified a cross-correlational model of an economical technique to code both absolute-range and range-profile information from a 3-dimensional acoustic image into a single spatial dimension of echo delay or target range. The animals behaved as though they imaged the echo delays arriving at each ear separately, and subjected those images to a left-right disparity comparison.

Report:
Simmons, J. A., Moss, C., & Ferragama, M. (1988). Target images in the sonar of bats (Tech. Rep. ONR-88-4). Providence, RI: Brown University.

TITLE: Signal Feature Analysis Using Neural Networks and Psychoacoustics

PRINCIPAL INVESTIGATOR: Nelson F. Steele
Advanced Resource Development Corp.
(301) 997-5600

R&T PROJECT CODE: 400o041

CONTRACT NO:

CURRENT END DATE: 31 DEC 1991

Objective:
To extract and contrast the features used by skilled sonar operators and several types of neural networks in classifying active sonar signals.

Approach:
Active sonar signals of known origin will be presented to sonar technicians and to several types of neural networks. Analyses will be carried out to determine the features used by each classifier in interpreting the signals.

Progress:
In their Phase I SBIR effort, the contractor demonstrated that neural networks of certain types were superior to trained human classifiers in interpreting active sonar signals, and that humans with access to the classifications of these networks were superior in their performance to those without such access.

TITLE: Committee on Hearing, Bioacoustics, and Biomechanics

PRINCIPAL INVESTIGATOR: Milton A. Whitcomb
National Academy of Sciences
CHABA
(202) 334-3024

R&T PROJECT CODE: 4426124

CONTRACT NO: N0001487C0342

CURRENT END DATE: 28 FEB 1991

Objective:
To provide information and assess status of current programs and to make recommendations on current and anticipated problems relevant to Navy and other federal agencies in the areas of hearing, bioacoustics, and biomechanics.

Approach:
Working groups address: effects of sound on hearing of divers during deep dives; exposure limits for vibration received by personnel in tracked vehicles and helicopters; effect of sonic booms produced by future commercial supersonic transport aircraft; auditory attentional deficit; evaluation of communication systems; aging in the central nervous system as it relates to perception of speech by older persons; and reversibility of presbycusis.

Progress:
Studies were completed on: (a) communication aids for the hearing-impaired; (b) evaluation of tests of vestibular function; (c) hazardous exposure to impulse noise; and (d) hazardous exposure to intermittent and steady-state noise. Conventional hearing aids, sensory substitution (such as vibrotactile and electrocutaneous stimulating devices), and cochlear implants were evaluated for their effectiveness in aiding speech reception by deaf and hearing-impaired persons. Recommendations were made for those classes of impaired listeners for whom the various aids were appropriate.

Report:
CHABA (1989). Removal of noise from noise-degraded speech signals. Washington, DC: National Academy Press. AD A212 876

TITLE: Conference on Bioacoustics Signal Classification

PRINCIPAL INVESTIGATOR: William A. Yost
Loyola University of Chicago
Parmly Hearing Institute
(312) 508-2710

R&T PROJECT CODE: 4424247

CONTRACT NO: N0001490J1428

CURRENT END DATE: 31 JAN 1991

Objective:
To conceptualize the critical research issues and methodologies appropriate for investigation under the POM 1991 ARI on bioacoustic signal classification.

Approach:
Twenty outstanding investigators have been invited to participate in a meeting on acoustic signal classification, with particular emphasis on biological solutions to the signal classification problem. Emphasis will be given to research problems and methodologies. This information will provide important guidance for management of the POM 1991 ARI on bioacoustic signal classification.

PERCEPTUAL SCIENCE

HAPTICS AND SENSORY GUIDED MOTOR CONTROL

TITLE: Conference on Motorsensory Systems

PRINCIPAL INVESTIGATOR: James H. Abbs
University of Wisconsin
Speech and Motor Control Laboratory
(608) 263-5907

R&T PROJECT CODE: 4421563

CONTRACT NO: N0001490J1892

CURRENT END DATE: 31 DEC 1990

Objective:
The purpose of the conference is to bring together scientists with interests in motorsensory processes from diverse disciplines (physiology, psychology, biomechanics, robotics) to discuss issues in the role of sensory information in the control of movement.

Approach:
The conference will consist of six topical sessions: central mechanisms, development, motor learning, adaptation, skill acquisition, and motorsensory impairment. Speakers will represent behavioral, biological, and biomechanical viewpoints.

Progress:
The conference will be held in October 1990.

TITLE: Neural Feedback and Musculo-Skeletal Mechanics

PRINCIPAL INVESTIGATOR: Emilio Bizzi and Neville Hogan
Massachusetts Institute of Technology
Department of Brain and Cognitive Sciences
(617) 253-5769

R&T PROJECT CODE: 4424216

CONTRACT NO: N0001490J1946

CURRENT END DATE: 31 MAY 1991

Objective:
Objective is to produce biologically plausible computational models of human arm and hand sensorimotor control for potential implementation in teleoperator and robotic devices.

Approach:
The approach is a combination of neurophysiological experiments, behavioral investigations, mathematical modeling and theoretical studies of the computational tasks performed by the brain in the control of motor behavior. Model-based experiments are conducted to quantitatively model movement planning, execution and functional manipulation.

Progress:
Neurophysiological studies of motor coordination were conducted with spinal frog preparations. Electrical microstimulation of the spinal cord coactivated groups of muscles, resulting in forces measured at the leg end point. The data constitute a set of samples of a time-varying force field. These fields were characterized by a single equilibrium point. This is the first experimental evidence that neural activation elicited by spinal stimulation corresponds to a movement of this equilibrium point. This result supports the virtual trajectory hypothesis of motion control.

Report:
Bizzi, E., and Mussa-Ivaldi, F.A. (1989) Emergent issues in the control of multi-joint movements. In L. Deecke (Ed.) From Neuron to Action. Springer-Verlag: Heidelberg.

TITLE: Tactile Sensing and Control in Humans and Robotic/Teleoperated Systems

PRINCIPAL INVESTIGATOR: Mark R. Cutkosky
Leland Stanford Junior University
Department of Mechanical Engineering
(415) 725-1588

R&T PROJECT CODE: 4424257

CONTRACT NO:

CURRENT END DATE: 30 SEP 1991

Objective:

(1) Create an integrated tactile sensing system with dynamic as well as conventional tactile and force sensors. (2) Develop signal processing algorithms that extract information needed for dexterous manipulation; determine the basic control modes and reflexes that take advantage of sensory information. (3) Investigate sensor-driven control strategies for precision manipulation in humans and use the findings to develop event-driven control strategies for robotic precision manipulation.

Approach:

Develop sensor configurations that result in largest and fastest signal for incipient slip detection. Use techniques such as adaptive filtering to optimize the sensor system for execution of simple manipulation tasks. Perform mechanical analysis of forces and motions required for a robotic assembly task, and analyze sensory requirements for successful completion of the task. Collaborate with the lab of R. Johansson on experiments aimed at understanding control strategies used by humans on assembly tasks. Use this information in design of sensor-driven control strategies for robotic manipulation.

Progress:

This grant is new in FY90.

TITLE: The Cortical Substrate of Haptic Representation

PRINCIPAL INVESTIGATOR: Joaquin M. Fuster
University of California, Los Angeles
UCLA School of Medicine
(213) 825-0247

R&T PROJECT CODE: 4425800

CONTRACT NO: N0001489J1805

CURRENT END DATE: 28 FEB 1992

Objective:
The primary objective of this work is to understand the functional organization of areas of primate cerebral cortex that represent tactile and visual information, with particular emphasis on the interaction of tactile and visual stimuli in the cortical representation of external objects.

Approach:
The role of posterior parietal cortex in the representation of physical objects will be explored by examining the effects of reversible cryogenic lesions of this cortical area in monkeys on short-term memory of haptically or visually perceived objects. Functional organization of parietal neurons during short term memory tasks will explored with microelectrode recording. Single unit recordings will also be analyzed to investigate neuronal mechanisms underlying attention to an object.

Progress:
Selective reversible lesions of posterior parietal cortex alter spontaneous and evoked activity of cells in prefrontal cortex in visual delayed matching to sample tasks, as well as patterns and speed of eye and hand movements during those tasks. Preliminary results suggest that cooling of prefrontal cortex impairs visual-to-haptic and haptic-to-haptic transfer of sensory information.

Report:
Koch, K. and Fuster, J.M. (1989) Unit activity in monkey parietal cortex related to haptic perception and temporary memory. Experimental Brain Research. 76, 292-306.

TITLE: Mechanisms of Eye-Hand Coordination

PRINCIPAL INVESTIGATOR: Apostolos P. Georgopoulos
The Johns Hopkins University
Department of Neuroscience
(301) 955-8334

R&T PROJECT CODE: 4424224

CONTRACT NO: N0001488K0751

CURRENT END DATE: 30 SEP 1991

Objective:
To elucidate the mechanisms of eye-hand coordination at the psychophysical (behavioral), neurophysiological, and computational levels.

Approach:
To define the behavioral capabilities of human and monkey subjects in eye-hand coordination, characterize the patterns of activity of single cells in the monkey motor cortex during eye-hand coordination tasks, and to model the involvement of neuronal populations in the motor cortex during the performance of such tasks.

Progress:
Monkeys were trained to move toward a light under one condition and 90 degrees counterclockwise from the light under another condition. The population vector as a function of time during this task was computed. When movement is 90 degrees counterclockwise from the light, the population vector undergoes a 90 degree rotation, from the direction of the light to the target position, prior to movement initiation.

Report:
Georgopulos, A.P., (1989) Eye-hand Coordination and Visual Control of Reaching: Studies in Behaving Animals. In W. Stebins and M. Berkeley (Eds.), Comparative Perception, New York: John Wiley, 375-403.

TITLE: Sensorimotor Control of Dexterous Manipulation by Humans

PRINCIPAL INVESTIGATOR: Roland S. Johansson
University of Umea
Department of Physiology

R&T PROJECT CODE: 4424250

CONTRACT NO: N0001490J1838

CURRENT END DATE: 30 SEP 1991

Objective:
To determine the processes by which sensory information is used to control the forces that are adapted to the changing loads on the motor system during a precision manipulation task.

Approach:
Muscle synergies and activation patterns are quantitatively analyzed from intrinsic and extrinsic muscles of the hand, and activity in single afferent mechanoreceptors of the hand is also recorded as a human operator performs an assembly task. The load and grip forces of the thumb and index finger are measured. The position of the object is monitored as are small slips of the grasped object.

Progress:
This grant is new in FY90.

TITLE: Motor Learning in Speech and Limb Movements: A Computational Approach

PRINCIPAL INVESTIGATOR: Michael I. Jordan
Massachusetts Institute of Technology
Department of Brain and Cognitive Sciences
(617) 253-1696

R&T PROJECT CODE: 4424253

CONTRACT NO: N0001490J1942

CURRENT END DATE: 30 JUN 1993

Objective:
The overall objective is the development of a computational theory of the production of coordinated movement in biological systems, both of the limbs and of the vocal apparatus.

Approach:
The approach will entail implementation of simulation models of an arm and a vocal tract. Two-joint and three-joint arm models will be simulated using standard rigid body dynamical equations, and will include simulated agonist and antagonist muscles at each joint based on a simple model of muscle dynamics. Vocal tract modeling will involve (1) a geometric model that relates articulator positions to vocal tract area functions, and (2) an acoustic model that combines vocal tract area functions with a source model to produce an acoustic spectrum.

Progress:
This grant is new in FY90.

TITLE: Modular Conceptions of Timing and Sequencing

PRINCIPAL INVESTIGATOR: Steven W. Keele
University of Oregon
Department of Psychology
(503) 686-5131

R&T PROJECT CODE: 4426802

CONTRACT NO: N0001487K0279

CURRENT END DATE: 31 MAR 1990

Objective:
The objective is to carry out behavioral experimentation with normals and brain damaged patients to establish the separability of the modular components of coordinated action and to demonstrate the central neural basis of each.

Approach:
Both normals and brain-damaged patients will be tested. Data taken from normals will be used to assess the independence of the timing, force, sequencing, and configuring components of coordinated motor function. Data from brain-damaged patients will be used to establish the anatomical basis of each component function.

Progress:
Recent contract work indicates (a) that sequence specification is independent of the specification of muscles that will execute the specified action, (b) that the cerebellum, especially the lateral cerebellum, is to a large extent specialized for temporal computation, and (c) that the basal ganglia are critical in regulating the force of different movements.

Report:
Irvy, R. & Keele, S. (1989) Timing functions of the cerebellum. *Cognitive Neuroscience*, 1, 136-152.

TITLE: Complex Sensorimotor Behavior: Biological Control Structures and Constraints

PRINCIPAL INVESTIGATOR: J.A.S. Kelso
Florida Atlantic University
Center for Complex Systems
(305) 538-2230

R&T PROJECT CODE: 4424223

CONTRACT NO: N0001488J1191

CURRENT END DATE: 31 JUL 1991

Objective:
To develop the theoretical and empirical base for a unified control theory of motor function, applicable across both rhythmic and discrete movement domains.

Approach:
To conduct psychophysical and motor performance experiments with human subjects and develop non-linear dynamical analyses the results of these experiments, leading to a formal theoretical formulation of the dynamics of sensory-guided reaching and grasping behavior.

Progress:
A paper describing a dynamic pattern theory of voluntary discrete movement behavior is in preparation. Key elements of this theory are that destabilizing signals contain no precoded information about the specifics of the trajectories, and that it is primarily the dynamics that define the trajectory shape and timing.

Report:
J. Kelso, (1989) Degrees of freedom, dynamical laws, and boundary conditions for discrete voluntary movement. Brain and Behavioral Sciences, 12, 189-250.
J. Kelso, G. Schoner (1988) Dynamics govern patterns of switching in biological movement. Physics Letters A, 134, 8-12.

TITLE: The Fourteenth International Symposium on Attention and Performance: A Silver Jubilee

PRINCIPAL INVESTIGATOR: Sylvan Kornblum
Regents of the University of Michigan
Department of Psychology
(313) 763-1101

R&T PROJECT CODE: 4424246

CONTRACT NO: N0001490J1488

CURRENT END DATE: 31 DEC 1991

Objective:
Understanding the role of attention in human information processing, motor control, and response timing is significant in the learning, retention, and execution of tasks by naval personnel.

Approach:
The symposium is being organized by the co-principal investigator aided by an organizing committee. The meeting will be held in Ann Arbor, MI., and will consist of daily sessions covering theoretical and experimental aspects of human attention and performance.

TITLE: Peripheral Neural Mechanisms of Haptic Touch: Softness and Shape

PRINCIPAL INVESTIGATOR: Robert H. LaMotte
Yale University
School of Medicine
(203) 785-2802

R&T PROJECT CODE: 4424218

CONTRACT NO: N0001490J1920

CURRENT END DATE: 30 JUL 1990

Objective:
The objective is to develop the psychophysical and neurobiological basis for biologically plausible computational models of human hand grasping and object manipulation for potential implementation in teleoperator and robotic devices.

Approach:
Psychophysical data from humans and monkeys and physiological data from monkeys will be gathered to determine the capabilities of these systems to discriminate softness and shape, and to determine the neural code underlying these discrimination capabilities.

Progress:
Slowly adapting afferents have been found to discriminate object surface curvature during both transient and steady state phases of tactile stimulation. A mechanical model of a deformable medium approximating a fingertip has been developed. This model can be used to calculate stresses and strains at any point in the medium for a given stimulus.

Report:
Srinivasan, M.A. (1989) Surface deflection of primate fingertip under line load. Journal of Biomechanics, 22, 343-349.

TITLE: Human Machine Interfaces for Teleoperators and Virtual Environments

PRINCIPAL INVESTIGATOR: Rudolph J. Yacyshyn
United Engineering Trustees, Inc.
(212) 705-7835

R&T PROJECT CODE: 4424248

CONTRACT NO: N0001490J1634

CURRENT END DATE: 15 JAN 1990

Objective:
To develop strategies and priorities for the conduct of research programs on human-machine interfaces for teleoperator and virtual-environment systems. To edit and compile the major papers presented at a conference on sensorimotor physiology and psychophysics, application areas, and current research issues related to telepresence, sensorimotor adaptation, evaluation procedures, and predictive models, for a book on the problem area.

Approach:
Forty outstanding investigators are invited to participate in a conference on human-machine interfaces for teleoperator and virtual-environment systems. Tutorial papers are presented on sensorimotor physiology and psychophysics, and application areas; seminars are provided on the topics of telepresence, sensorimotor adaptation, evaluation procedures, and predictive models; and poster sessions report on current research programs on the foregoing issues. Ten students are invited to attend.

PERCEPTUAL SCIENCE

HUMAN FACTORS TECHNOLOGY

TITLE: Personalized and Prescribed Information Handling

PRINCIPAL INVESTIGATOR: Luiz Cabral
Naval Underwater Systems Center
Newport Laboratory
(401) 841-2648

R&T PROJECT CODE: 4429013

CONTRACT NO: N0001490WX24202

CURRENT END DATE:

Objective:
To test theories of information-handling under conditions of variable uncertainty of the information and at different levels of risk to the decision-maker. To assess the effectiveness of personalized and prescriptive display systems for decision support by experienced Naval officers within an interactive submarine engagement simulation.

Approach:
To conduct pilot and formal experiments that assess the effectiveness of personalized and prescriptive information-handling systems during submarine tactical-attack planning and situation assessment, and that provide comparative results of unaided human performance. Performance in an interactive submarine engagement simulation measures effectiveness under high situational uncertainty, high risk to own ship, and when available estimates of the situational parameters conflict.

Progress:
Evidential-reasoning algorithms were incorporated into the submarine-attack simulations, user interfaces were designed for personalized and prescriptive information-handling systems, and submarine-attack scenarios were developed. Initial testing of these experimental design features was completed.

Report:
Cabral, L. (1989). Decision support for submarine attack planning (Tech. Memo. 89-2097). Newport, RI: Naval Underwater Systems Center.

Outside Funding:
Funds for this project are provided by ONT Code 222.

TITLE: Cognitive Factors Affecting Sonar Classification

PRINCIPAL INVESTIGATOR: Marvin S. Cohen
Decision Science Consortium Incorporated
(703) 620-0660

R&T PROJECT CODE: 4429012

CONTRACT NO: N0001489C0229

CURRENT END DATE: 30 SEP 1992

Objective:
To design and conduct experimental studies that will elicit the role of cognitive factors in the sonar classification task, using skilled sonar operators as participants. To develop a normative model of sonar operator decision behavior in that task.

Approach:
To merge prior research data on signal classification and decision-making, collect experimental data on the sources of bias found in skilled sonar operators, specify the cognitive factors in the classification decision, and develop a normative model of classification behavior.

Progress:
Prior research on classification performance was reviewed and sources of perceptual/cognitive bias were identified. An interactive display system for sonar classification decisions was designed and an inference model for a normative solution to a classification problem (integration of signal data with knowledge of the causes and time relations of an event, and the specification of base-rate data for that event) was developed; both components were incorporated into a personalized and prescriptive system.

Outside Funding:
Funds for this project are provided by ONT Code 222.

TITLE: Classification of Single Epoch Evoked Potentials with (EP) and Evoked Magnetic Fields (ES) Using Neural Network

PRINCIPAL INVESTIGATOR: Sushil DasGupta
Temple University
Department of Electrical Engineering
(215) 787-7932

R&T PROJECT CODE: 4424238

CONTRACT NO: N0001489J1978

CURRENT END DATE: 30 APR 1990

Objective:
The objective is to comparatively evaluate several alternative neural networks with respect to their utility in classifying single epoch evoked potentials and evoked magnetic fields with respect to their relation to psychophysical performance.

Approach:
Several alternative neural networks, including Bidirectional Associated Memory, multilayered Back propogation, and Counter propogation, will be compared with respect to their capability to classify single epoch (or epoch averaged) evoked potentials and evoked magnetic fields recorded during a prior psychophysical experiment at NPRDC.

Progress:
A general neural network classification performance evaluation technique was developed. Inner product and distance measures were applied to the peak amplitudes appearing in the first half of the subject's ERP responses. This method was used to predict the subject's recognition as to whether a stimulus was a target or non-target. Backpropagation networks with a third layer were found superior to those containing only two layers in predicting the subjects' recognition responses.

Outside Funding:
Funds for this project are provided by ONT Code 222.

TITLE: NRC-Committee on Human Factors

PRINCIPAL INVESTIGATOR: Michael A. Drillings
U.S. Army Research Institute
(202) 274-5572

R&T PROJECT CODE: 4424167

CONTRACT NO: N0001490MP24035

CURRENT END DATE: 30 NOV 1987

Objective:
To conduct analytic studies, workshops, symposia, and gather the requisite data to evaluate current theories, topics, and problems in human performance.

Approach:
To define and address problems in human performance of relevance to sponsor's programs, assemble experts in those areas, and analyze the available data through the medium of jointly-authored reports, workshops, or symposia. The programs include: (a) research needs for human factors; (b) augmentation of intellectual functioning; (c) human factors standards; and (d) studies of disabled/handicapped.

Progress:
Studies were completed that reviewed current models of human performance, identified those that would be most useful for a computer-aided engineering facility; and recommended research on models and modeling that might cover some existing limitations. Focus was on visual and associated cognitive functions required of pilots in the operation of advanced helicopters.

Report:
Elkind, J. I., Card, S. K., Hochberg, J., & Huey, B. M. (Eds.). (1989). Human performance models for computer-aided engineering. Washington, DC: National Academy of Sciences.

Outside Funding:
Funds for this project are provided by ONT Code 222.

TITLE: Research on Reduced-Capability Human Hands

PRINCIPAL INVESTIGATOR: Nathaniel Durlach
Massachusetts Institute of Technology
Research Laboratory of Electronics
(617) 253-3922

R&T PROJECT CODE: 4424249

CONTRACT NO: N0001490J1935

CURRENT END DATE: 14 MAY 1992

Objective:
The general objectives of the research are to increase basic knowledge of hand function, aid in the design and evaluation of artificial hands for robotic and teleoperator systems, and provide background for master/slave hand-design decisions.

Approach:
The degradation of analytic and functional manual performance resulting from imposition of a variety of constraints will be investigated experimentally. Functional tests include tasks drawn from those developed at NOSC for testing the TOPS teleoperator system. Constraints include mechanical interferences (e.g., gloves), anesthetics, cold water, and hand impairments of the kinds caused by injury.

Progress:
This grant is new in FY90.

Outside Funding:
Funds for this project are provided by ONT Code 222.

TITLE: Electrophysiological Studies of Visual Attention and Resource Allocation

PRINCIPAL INVESTIGATOR: Steven A. Hillyard
University of California, San Diego
Department of Neurosciences
(619) 534-2385

R&T PROJECT CODE: 4424232

CONTRACT NO: N0001490J1911

CURRENT END DATE: 28 FEB 1991

Objective:
To evaluate the utility of evoked-potential methods for the on-line assessment of operator cognitive states (alertness, attentional focus) during tasks requiring the monitoring of several sources of information.

Approach:
An irrelevant probe technique is employed to elicit event-related potentials (N1 and N2 waves) to index the allocation of attention between competing tasks and competing sensory channels. Another event-related potential (P300) is utilized to assess decision confidence and signal detectability during sustained task (simulated sonar) performance. Workload conditions are varied by manipulating the signal-to-noise ratio and the frequency of the target presentations.

Progress:
Pilot studies have verified that both auditory and visual N1 waves during irrelevant probes show increased amplitudes when operators attend to relevant information in the same sensory channel. As operators became less alert, the amplitude of the N1 wave decreased while the amplitude of the N2 wave increased. During sustained task performance, the P300 wave differentiated between missed and correctly-detected targets.

Outside Funding:
Funds for this project are provided by ONT Code 222.

TITLE: Automatic Characterization of the Human Operator Dynamics and Its Incorporation into Telerobot Control

PRINCIPAL INVESTIGATOR: John M. Hollerbach
McGill University
Department of Biomedical Engineering
(514) 398-6736

R&T PROJECT CODE: 4424239

CONTRACT NO: N0001490J1849

CURRENT END DATE: 31 MAY 1993

Objective:
To develop scientific instrumentation and methods for the analysis of single joint, quasi-static movement in human operators and manipulators. To utilize knowledge of human operator dynamics to improve teleoperation of the manipulator for pursuit tracking.

Approach:
Determine the mechanical properties of the actuator linkage of the experimental apparatus. Determine overall human operator dynamics in visual pursuit tracking of position with several forms of target presentation. Apply a random force-step to the wrist of human operators and instruct the operator to resist that force in such a way that the elbow joint does not change. Several methods are developed to indicate when the elbow angle has been perturbed by the force step.

Progress:
This grant is new in FY90.

Outside Funding:
Funds for this project are provided by ONT Code 222.

TITLE: Decision Making in Naval Command Teams

PRINCIPAL INVESTIGATOR: David L. Kleinman
University of Connecticut
Department of Electrical and Systems Engineering
(803) 486-3066

R&T PROJECT CODE: 4429010

CONTRACT NO: N0001488K0545

CURRENT END DATE: 31 AUG 1991

Objective:
To investigate decision strategies, information structures, communication protocols, and process feedback as mechanisms to improve coordination in resource allocation and management tasks in command-and-control systems.

Approach:
A testbed implemented as a composite warfare commander distributed dynamic decisionmaking simulation is utilized for the conduct of experiments that investigate the effectiveness of decision strategies under time stress, degraded communications, and resource constraints. Other experiments will examine the role of a leader in (re)allocating resources and different modes of resource transfer within a team, and the manipulation of the information structure of the team for the reduction of resource contention conflicts.

Progress:
A distributed dynamic simulation was designed and coded to examine distributed decisionmaking issues in a four-person hierarchical team of naval commanders who are planning, coordinating, and allocating resources. The simulation was modified to include a model of the effects of stress on human biases and decisionmaking.

Report:
Kleinman, D. L., & Serfaty, D. (1989). Team performance assessment in distributed decisionmaking. In Proceedings of Symposium on Interactive Networking for Simulation. Orlando, FL: Naval Training Systems Center.

Outside Funding:
Funds for this project are provided by ONT Code 222.

TITLE: An Electrophysiological and Behavioral Examination of Bimodal Information Processing

PRINCIPAL INVESTIGATOR: David A. Kobus
Naval Health Research Center
Sustained Operations Department
(619) 553-9389

R&T PROJECT CODE: 4424256

CONTRACT NO: N0001490WR24022

CURRENT END DATE: 30 APR 1993

Objective:
To determine the information-bearing parameters used by superior sonar classifiers in making classification judgments, and to determine the relative contributions of visual and auditory cues in making such judgments.

Approach:
Psychophysical experiments will be carried out using auditory, visual or bimodal displays of sonar or sonar-like signals. Subjects will per-form a variety of tasks, including classification, discrimination, and similarity ratings. The resulting data will be subjected to multi-dimensional scaling and cluster analysis to extract the features used in making the psychophysical judgments obtained.

Progress:
This grant is new in FY90.

Outside Funding:
Funds for this project are provided by ONT Code 222.

TITLE: Effects of Fatigue on Skilled Performance

PRINCIPAL INVESTIGATOR: Arthur F. Kramer
University of Illinois
Institute of Aviation
(217) 333-2186

R&T PROJECT CODE: 4429015

CONTRACT NO: N0001490J1586

CURRENT END DATE: 14 FEB 1991

Objective:
To determine the sensitivity of measures of event-related potentials for the assessment of real-time variations in processing demands for multi-task situations. To examine the efficacy of workload assessment techniques (primary and secondary task measures; irrelevant probe techniques) for multi-task performance in real-time.

Approach:
Human performance measures, subjective ratings, and event-related potentials are collected from operators during multi-task situations. Different techniques are applied to the event-related-potential data to determine the amount and type of data that optimally discriminate performance among several difficulty levels and types of tasks. The goal is to develop a single-trial pattern-recognition technique for on-line assessment of operator state.

Progress:
Several experiments have been carried out to assess the efficacy of alternative techniques for assessing the mental workload demands of Navy-relevant information-processing tasks carried out over protracted periods of time.

Outside Funding:
Funds for this project are provided by ONT Code 222.

TITLE: Integrated Computational Models of Perceptual Performance

PRINCIPAL INVESTIGATOR: William R. Uttal
Arizona State University
Department of Psychology
(602) 965-3326

R&T PROJECT CODE: 4429011

CONTRACT NO: N0001488K0603

CURRENT END DATE: 31 JUL 1992

Objective:
To conduct simulations that test a software system for the integration of existing algorithms for the detection, localization, and classification of 3-D objects in the underwater environment. To evaluate the general utility of the simulation as a test bed for refinements of the computational algorithms.

Approach:
To collect and integrate a collection of individual computational algorithms into a coherent software system capable of simulating the performance of a 'swimmer' that is required to detect and recognize regular geometrical objects, locate them in 3-D space, and then navigate toward them.

Progress:
Substantial progress has been achieved in developing and refining an integrated vision system for application in the design of autonomous or semi-autonomous underwater vehicles. Major developments over the past several months have been in the refinement of the object recognition components of the system.

Outside Funding:
Funds for this project are provided by ONT Code 222.

BIOLOGICAL INTELLIGENCE

COMPUTATION IN LARGE NEURAL NETWORKS

TITLE: Changes in Neuronal Network Properties Induced by Learning and Synaptic Plasticity

PRINCIPAL INVESTIGATOR: Theodore W. Berger
University of Pittsburgh
Dept of Behavioral Neuroscience
(412) 624-4562

R&T PROJECT CODE: 4426817

CONTRACT NO: N0001487K0472

CURRENT END DATE: 31 MAY 1990

Objective:
Investigate potential changes in system properties of the hippocampus induced by discrimination reversal conditioning of the nictitating membrane (NM) response. Classical conditioning of the rabbit NM response will be used in these experiments because it is one of the most widely used behavioral paradigms for the studying of the neuronal substrates of associative learning in mammals. The second objective is to produce a computational structure which simulates the hippocampal system functions of learning and memory.

Approach:
The approach of this proposal is an in-depth study of the functional network properties of the hippocampal formation, a brain structure long known to be critical for learning and memory functions. The first phase utilizes nonlinear systems analytic techniques to characterize the transformational properties of networks of neurons comprising the hippocampus and thereby, to define the contributions to network properties of individual subpopulations of hippocampal neurons. The second phase, involves the formulation of a state-space model of hippocampal system function based on results from the nonlinear systems characteristics of the hippocampus.

Progress:
The PI extended his analysis of nonlinear response properties of the dentate gyrus to the in vitro hippocampal slice. The slice preparations are being used to determine the individual contribution of each of the sources of feedback to dentate granule cells from other components of the hippocampal formation and from intrinsic sources within the dentate gyrus.

Report:
Berger, T. Harty, T., Barrinuevo, G., Sclabassi, R.J. (1990) Modeling of neuronal networks through experimental decomposition. In V.Z. Marmarelis (Ed.) Advanced Methods of Physiological System Modeling. N.Y. Plenum.

TITLE: Computational Theory and the Olfactory System

PRINCIPAL INVESTIGATOR: James M. Bower
California Institute of Technology
Biology Division
(818) 356-6817

R&T PROJECT CODE: 4426136

CONTRACT NO: N0001488K0513

CURRENT END DATE: 30 JUN 1991

Objective:
The overall objective of the project is to attempt to forge a link between the components of abstract neural network processing and the detailed anatomy and physiology of an actual neural system. This project links the more theoretical neural network models studied by Hopfield to the actual structural components of the olfactory system.

Approach:
This project will develop physiological techniques for recording neuronal activity in behaving animals (albino rats). Initially, this approach will involve recording simultaneously from numerous neurons in the mitral cell layer of the olfactory bulb while the animal is performing olfactory discrimination tasks. In these experiments, the primary objective will be to determine the nature of stimulus encoding in the olfactory system and the role of this encoding in learning and memory.

Progress:
The PI has conducted investigations of olfactory cortex employing a combination of realistic computer simulations, in vitro electrophysiology, and in vivo multiunit recording. The computer simulations have expanded to parallel computers which enable a simulation of tens of thousands of biophysically realistic neurons. The cortical distribution of receptor types has been included, and a simulated olfactory bulb linked to the olfactory cortex. Real pyramidal neurons are being stimulated to fire in the same pattern predicted from the simulations, in order to examine whether this pattern is essential for LTP production.

Report:
Bower, JM (1989) Reverse engineering the nervous system: An anatomical, physiological, and computer based approach. In: An Introduction to Neural and Electronic Networks. S. Zornetzer, J. Davis, C. Lau, Eds., Academic Press.
Wilson, M, Bower, JM (1989) The simulation of large-scale neuronal networks. In: Methods in Neuronal Modelling, C. Koch & I. Segev, Eds., MIT Press.

TITLE: Dynamic Biophysical Theory for the Role of Hippocampal Neural Networks in the Declarative Memory System

PRINCIPAL INVESTIGATOR: Thomas H. Brown
Yale University
Department of Psychology
(818) 357-9711

R&T PROJECT CODE: 4426200

CONTRACT NO: N0001488K0313

CURRENT END DATE: 30 JUN 1991

Objective:
The objective is an understanding of how the circuitry of the hippocampus carries out its adaptive functions. The network-level model will have three features.

1. It will capture the time-dependent aspects of neural computation, i.e., the neurodynamics
2. It will show how the neurodynamics emerge from the cellular neurophysiology and biophysics
3. The model will be tightly linked to experimental knowledge of the cellular neurophysiology and biophysics.

Approach:
Using brain slice techniques, whole neurones will be examined to form realistic representations of the principle neuronal types (e.g. CA1 and CA3 pyramidal neurones, granule and basket cells). Voltage signalling throughout the dendritic authorization will be explored. In addition, I/O (synaptic input to spike output) will be quantified to understand the adaptive network neurodynamics.

Progress:
Computer simulations have been accelerated and expanded and now include more realistic description of several biophysical processes involved in LTP induction. A whole neuron model with voltage dependent conductances has been constructed to explore spatio-temporal properties of LTP induction.

Report:

Brown, T.H., Kairiss, E.W., & Keenan, C.L. (1990) Hebbian synapses: Biophysical mechanisms and algorithms. Ann. Review of Neuroscience, 13, 475-511.
Zador, A., Koch, C., & Brown, T. (1990) Biophysical model of a Hebbian synapse. Proc. Nat'l. Acad. Sci. (in press).

TITLE: Theoretical and Experimental Research into Biological Mechanisms Underlying Learning and Memory

PRINCIPAL INVESTIGATOR: Leon N. Cooper
Brown University
Center for Neural Science
(401) 863-2585

R&T PROJECT CODE: 4426830

CONTRACT NO: N0001486K0041

CURRENT END DATE: 31 DEC 1990

Objective:
Detailed objectives include the following: to clarify the dependence of learning on synaptic modification, to elucidate the principles that govern synapse formation or modification - both local factors and global information such as that which may be delivered and/or mediated by neuromodulators, to use principles of organization that can account for observations on a cellular level to construct network models that can compute, and reproduce higher level cognitive acts.

Approach:
Approaches include both theory and experiment. Theoretical and experimental consequences of the hypothesis that synapse modification is dependent on local information (in visual cortex) in accordance with theoretical ideas the authors have developed, as well as by global instructions affecting large numbers of synapses and coming from neuromodulators. Various principles that appear to be operating on the cellular level will be used to construct models of higher level functions, including various network models for memory storage, computation and language acquisition.

Progress:
The PI's data demonstrate that the site of binocular competition in the control of LGN cell size is the striate cortex, and because NMDA receptors are not presynaptic, that binocular competition requires postsynaptic activity. Further, the data suggest that the relevant component of post-synaptic activity depends specifically upon NMDA receptor activation.

Report:
Bear, MF, Involvement of excitatory amino acid receptors in the experience dependent development of visual cortex. In: Recent Advances in Excitatory Amino Acid Research, J Lehman, Ed., Liss, New York, in press.
Bear, MF and Cooper, LN (1990) Molecular mechanisms for synaptic modification in the visual cortex: interaction between theory and experiment. In: Neuroscience and Connectionist Theory, M Gluck & D Rumelhart, Eds.

TITLE: Net Technical Assessments of ANN (Neural Network) Technologies

PRINCIPAL INVESTIGATOR: Robert B. Davidson
Science Applications International Corp.
Technology Research Group
(703) 821-4418

R&T PROJECT CODE: a44f003

CONTRACT NO: N0001489C0243

CURRENT END DATE: 09 AUG 1991

Objective:
The objective of the study is to: (a) evaluate the comparative performance capability of neural networks applied to signal processing tasks (incl: sonar signal identification, and automatic target recognition), and (b) evaluate the emerging national and international technological capabilities in this area.

Approach:
Preparation of a computerized database of neural network technology involves (a) a thorough review and analysis of publications, and technical reports, and (b) host symposia of nationally recognized experts on neural network theory and technology. This team includes several current ONR contractors in ONR's ARI in Biological and Electronic Neural Networks: Leon Cooper, Jerome Feldman, John Hopfield, Carver Mead, and Terrence Sejnowski. Three state-of-the-art symposia will be conducted on the three main topics of the DARPA program: (a) Comparative Performance of Neural Networks, (b) Theory & Modelling, and (c) Hardware Technology.

Progress:
Procured and integrated two DARPA artificial neural network technology database workstations. After evaluating preliminary, rapid prototypes in each of three competing development environments, completed a full prototype DARPA ANNT database management system (written in 4th Dimension for Macintosh) for use and refinement. Prepared briefing materials summarizing present and projected state of the art in each of the areas of the DARPA program (Applications, Architecture, Hardware Technology). Completed a preliminary survey of ANNT activities in Europe including site visits to key installations, made with DARPA and ONR program managers.

Ouside Funding:
Funds for this project are provided by DARPA.

TITLE: International Symposium on Neural Networks for Sensory and Motor Systems (NSMS)

PRINCIPAL INVESTIGATOR: Rolf Eckmiller
Heinrich - Heine
Division of Biocybernetics, Depart Biophysics
(202) 696-4744

R&T PROJECT CODE: 442h011

CONTRACT NO: N0001490J1378

CURRENT END DATE: 15 SEP 1990

Objective:
Understanding and application of biological principles to neural networks requires a true interdisciplinary effort between two segments of the scientific community that has few historical examples. This conference is designed to facilitate interactions between those who study biological neural networks and those who seek to emulate their functions in solving real world problems.

Progress:
Proceedings of this symposium are due to be published by Elsevier Press late in 1990.

TITLE: Selective Recognition Automata

PRINCIPAL INVESTIGATOR: Gerald M. Edelman
Neurosciences Research Foundation, Inc.
(212) 570-8975

R&T PROJECT CODE: 4426129

CONTRACT NO: N0001488K0411

CURRENT END DATE: 31 JUL 1991

Objective:
The major goal of this project is to carry out critical tests of the neuronal group selection theory that will bring selective automata closer to practical application. Specific technical objectives: to account for the regulation of plastic changes in topographic cortical maps, to demonstrate associative learning in selective recognition systems, to study mechanisms for figure-ground discrimination and perceptual constancy in selective systems, to generalize the concept of topographic maps to encompass "cognitive maps" in world-centered coordinate frames, and to represent temporal sequences of events in selective network systems.

Approach:
An approach called "synthetic neural modelling" will be applied to the objectives. This approach depends on starting with a coherent theory of brain function and testing that theory by constructing model automata that follow principles of biological evolution and development.

Progress:
A new simulation for studying mechanisms of integration in the visual cortex has been developed, based on a model called Reentrant Cortical Integration. It incorporates areas subserving three visual submodalities (orientation, motion, and occlusion), and the activity of these functionally segregated areas is integrated by reentrant signaling. A new simulation for studying correlated activity among local populations of neuronal elements has been developed. It reproduces recent experimental data on oscillatory activity in the visual cortex and also provides insights into how function of distinct cortical areas can be coordinated.

Report:
Finkel, LH, Reeke, GN Jr, Edelman, GM (1989) A population approach to the neural basis of perceptual categorization. In: Neural Connections, Mental Computation, Ed. L. Nadel et. al., Bradford Books, MIT Press, Cambridge
Finkel, LH & Edelman, GM (1989) Integration of distributed cortical systems by reentry: A computer simulation of interactive functionally segregated visual areas. J. Neurosci. 9.

TITLE: Olfaction as a Model System for Computational Neuroscience

PRINCIPAL INVESTIGATOR: Howard Eichenbaum
Wellesley College
(202) 696-4744

R&T PROJECT CODE: 4426421

CONTRACT NO: N0001490J1468

CURRENT END DATE: 01 SEP 1990

Objective:

At this time there is a confluence of interest in the olfactory system that spans a wide range of expertise and offers a model system for computational analysis that bears on issues of importance to ONR (chemical sensors and biological intelligence).The objective is to stimulate the close interaction of experts to reveal the qualities of this system that should be most important to investigators at all levels.

Approach:

A conference of 14 investigators will convene at Wellesley College on May 16-17, 1990. The presenters are eminent neuroscientists who represent various computational approaches to the olfactory system. There will be an invited presentation on hardware implementation of olfaction models and a book will be generated from chapter submissions by the 14 major participants.

Progress:

The proceedings of this symposium will be published by MIT Press early in 1991.

TITLE: Connectionist Models Summer School

PRINCIPAL INVESTIGATOR: Jeffrey L. Elman
University of California, San Diego
Institute for Neural Computation
(619) 534-1147

R&T PROJECT CODE: 4426404

CONTRACT NO: N0001490J1843

CURRENT END DATE: 30 SEP 1990

Objective:
The purpose of this summer school is to assist in the training of young researchers in the area of neural networks and adaptive systems.

Approach:
A ten day intensive course entitled "1990 Connectionist Models Summer School" will be held at UCSD. 50 graduate students will be admitted via a competitive admissions process. 25 faculty will present lectures and discussion on the topics of: learning, neuroscience modeling, symbols, language, knowledge representation, and neuroengineering. The proceedings will be published.

TITLE: Interaction between the Immune System and Neural Plasticity

PRINCIPAL INVESTIGATOR: Fred H. Gage
University of California, San Diego
Neurosciences
(619) 452-2416

R&T PROJECT CODE: 4426016

CONTRACT NO: N0001490J1116

CURRENT END DATE: 31 OCT 1990

Objective:
Explore the interaction between the immune system and neuronal plasticity during the process of neuronal sprouting following lesioning of selected structures.

Approach:
Experiments will be performed to determine how neural response to injury influences the release of regulatory factors such as cytokines, and how they in turn regulate neural mechanisms of repair.

Progress:
Damage to the fimbria-fornix, and separately to the perforant path, leads to distinct and dramatic time-dependent increases in glial fibrillary acidic protein immunoreactivity (GFAP-IR) in specific areas of the hippo-campal formation (Gage et al.,1988). Adult cholinergic interneurons of the neostriatum are not immunoreactive for monoclonal antibody to NGF receptor, whereas the developing neostriatum is immunoreactive for this same antibody (Gage et al., 1989).

Report:
Gage, F.H., Olejniczak, P., and Armstrong, D.M. (1988) Astrocytes are important for sprouting in the septohippocampal circuit. Experimental Neurology 102: 2-13.
Gage, F.H., Batchelor, P., Chen, K.S., Higgins, G.A., Koh, H.S., Deputy, S., Rosenberg, M.B., Fischer, W. and Bjorkland, A. (1989) NGF receptor re-expression and NGF mediated cholinergic neuronal hypertrophy in the damaged adult neostriatum. Neuron, 2: 1177-1184.

TITLE: Training in Methods in Computational Neuroscience

PRINCIPAL INVESTIGATOR: Harlyn O. Halvorson
Marine Biological Laboratory
(508) 548-3705

R&T PROJECT CODE: 442h004

CONTRACT NO: N0001490J1965

CURRENT END DATE: 30 SEP 1990

Objective:
The primary aim of the course is to provide the 20 participants with the tools to simulate the functional properties of those neural systems of interest as well as to understand the general advantages and disadvantages of this experimental approach.

Approach:
The lectures are presented by the course directors (James Bower & Christof Koch-Caltech) and invited faculty (Paul Adams, Dan Alkon, Richard Andersen, John Hildebrand, John Hopfield, Rudolfo Llinas, John Rinzel, David Rumelhart, Idan Segev, Terrence Sejnowski, David Van Essen, and Christof Von der Malsburg). The computer laboratory provides students with the opportunity to begin simulations of neural systems. The lab will be equipped with loaned Sun graphics workstations running the General Network Simulation System which was created with ONR support by James Bower.

TITLE: Silicon Association Cortex

PRINCIPAL INVESTIGATOR: Dan Hammerstrom
Oregon Graduate Center
Department of Computer Science/Engineering
(503) 690-1160

R&T PROJECT CODE: 442h020

CONTRACT NO: N0001490J1349

CURRENT END DATE: 31 DEC 1991

Objective:
The objective is the silicon implementation of two existing cortex-like models. Implementation of basic silicon cortex will greatly accelerate the development of neurobiological models by providing a means for much speedier and cost effective simulation.

Approach:
The PI will use only state-of-the-art CMOS technology, since neural networks will only be viable commercially when implemented in cheap, mass producible technology. The close, active collaboration between the hardware designers and the wetware scientists will ensure a faithful representation of the model.

Progress:
This grant is new in FY90.

TITLE: Studies in Neural Networks

PRINCIPAL INVESTIGATOR: John J. Hopfield
California Institute of Technology
Chemistry
(818) 356-6034

R&T PROJECT CODE: 4426803

CONTRACT NO: N0001487K0377

CURRENT END DATE: 31 MAY 1990

Objective:
Objectives are to put the olfactory problem in biology into a computational perspective; construct model neural networks which can solve some of the computational problems of olfaction; examine the connections between the model networks and the real olfactory networks; and to understand the importance of the time-dependent aspects of olfactory processing.

Approach:
The dominant approach is through studying the mathematics of the computations involved, and simulations of appropriate neural networks on conventional computers. In olfaction, important experimental input to the research is on-going work at Caltech. In the case of speech, experimental data will be obtained from real verbal signals.

Progress:
A neural network model based on olfactory bulb anatomy and physiology was built, mathematically analysed, and computer simulated. The model mimics very well the observed oscillatory activities observed in the neuron population of the bulb. An artificial "neural network" was constructed to recognize a small vocabulary of words in continuous speech. The network is designed on principles known to be used in mammalian auditory systems including place coded frequency band neurons.

Report:
Li, Z. and Hopfield, J.J. (1989) Modeling the Olfactory Bulb and Its Neural Oscillatory Processings. Biological Cybernetics, in press.
Unnikrishnan, K.P., Hopfield, J.J. and Tank, D.W. (1989) Connected-Digit Speaker-Dependent Speech Recognition using a Neural Network with Time-Delayed Connections. IEEE, in press.

Outside Funding:
This project is jointly funded with ONR Electronics Division.

TITLE: Adaptive Control of Limb Motion by Brains and Robots

PRINCIPAL INVESTIGATOR: James C. Houk
Northwestern University
Department of Physiology
(312) 908-8219

R&T PROJECT CODE: 4426126

CONTRACT NO: N0001490J1822

CURRENT END DATE: 31 MAY 1993

Objective:
The proposal is designed to advance knowledge about how the cerebellum might mediate adaptive feedforward control, and to apply this information to robotics.

Approach:
The investigators will conduct computer simulations of motor systems, in the form of simulated neural networks, that are based on the anatomy and physiology of the cerebellum. More specifically, the investigators are interested in the functional and computational significance of the findings that will result from the mapping of mossy-fibre inputs to cerebellar cortex. Consequently, the investigators will develop and simulate networks of neuron-like units whose architectures and roles in motor control are based on anatomical and physiological knowledge.

Progress:
In a comparison of movement related properties of input and output cerebellar functions it was found that virtually all output elements reacted strongly during natural reaching movements, but only 10% discharged at high rates during a tracking task.Input elements responded well under both conditions.Secondly, a simulation model of a single cerebellorubral module (an adjustable motor pattern generator) was developed. Thirdly, realistic models of muscle reflex systems were completed including separate representations of muscle mechanical and spinal reflex mechanisms.

Report:
Houk, J.C., Wu, C., & Young, K. (1989) Nonlinear damping of limb motion. Physiol. Sci.Abs.: 533.
Houk, J.C. (1989) Cooperative control of limb movements by the motor cortex, brainstem, and cerebellum. In: Models of Brain Function, R.M.J. Cotterrill (Ed.) Cambridge Univ. Press. pgs.309-326.

TITLE: Dynamic Biophysical Theory for the Role of Hippocampal Neural Networks in the Declarative Memory System

PRINCIPAL INVESTIGATOR: Christof Koch
California Institute of Technology
Div. of Biology & Engineering and Appl.Sci.
(818) 356-6855

R&T PROJECT CODE: 4426201

CONTRACT NO: N0001488K0297

CURRENT END DATE: 30 JUN 1991

Objective:
Koch will develop appropriate algorithms for carrying out hippocampal simulations. One focus will be the detailed biophysical events possibly underlying induction of LTP in dendritic spines and single pyramidal cells. In parallel, the second focus will be a network model of the entire hippocampal structure. The two models will provide an organizational substrate to suggest and generate new biological experiments.

Approach:
In collaboration with a second ONR contractor, the PI proposes to begin construction of a viable and testable network-level theory of the nature of the information processing that occurs in mammalian central nervous systems. The theory will combine the best neural modelling techniques with state-of-the-art cellular neurobiological experimentation. This contract represents the higher-level or top-down (computational) approach that will serve to guide the bottom-up (neuroscience) strategy.

Progress:
Associative learning in Hermissenda is mediated by cellular interactions between two sensory pathways and is stored by modulation of two potassium channels. Computer simulations of biophysical properties reveal changes in timing of the light mediated depolarization as a result of changing activation rate of these two conductances.

Report:
Zador, A., Koch, C., and Brown, T. (1990) Biophysical model of a Hebbian synapse. Proc. Nat'l. Academy of Sciences (in press).

TITLE: Long-Term Potentiation: A Debate of Current Issues

PRINCIPAL INVESTIGATOR: Serge Laroche
Centre National De La Recherche Scientifique
Departement de Psychophysiologie
(213) 743-8024

R&T PROJECT CODE: 4426330

CONTRACT NO: N0001490J1927

CURRENT END DATE: 30 DEC 1990

Objective:
This symposium will provide a unique opportunity to critically evaluate the existing data and hypotheses regarding Long Term Potentiation (LTP) and to reach a consensus between competing laboratories in Europe and the US on some of the most salient issues. In addition this symposium will generate new hypotheses, theories, ideas and collaborative experiments that might otherwise take much longer to be initiated. The proceedings of this meeting will be published by MIT press.

Approach:
A small symposium (20-30 participants and rapporteurs) organized following the models of The Neuroscience Research Programs and the Dahlem conferences is an ideal forum to promote the type of exchange and interaction between European and American scientists required to clarify current issues in the LTP field. The meeting will last three days and is hosted by the French Government (CNRS). Morning and Afternoon sessions will debate a specific issue with speakers providing a multinational perspective.

Report:
The proceedings of this conference will be published by MIT Press in 1991.

TITLE: Analysis and Simulation of a Cortical Network

PRINCIPAL INVESTIGATOR: Gary Lynch
University of California, Irvine
Center for Neurobiology of Learning and Memory
(714) 856-4274

R&T PROJECT CODE: 442h010

CONTRACT NO: N0001489J1255

CURRENT END DATE: 30 SEP 1991

Objective:
The objective is an understanding of the types of learning operations carried out by simple cortical networks. This requires research at four different levels: (1) neurobiology, (2) simulations and mathematical analysis, (3) behavioral neurophysiology (i.e., chronic recording), and (4) behavior.

Approach:
The approach is to ask how complex sets of physiological variables govern the collective activity of neurons in brain networks, and whether these aggregate activities might produce recognizable behavioral events. Using this strategy, the plan is to develop general formulations stated in basic biological terms that relate physiology and anatomy to particular aspects of memory.

Progress:
A computer simulation of a mammalian olfactory bulb glomerulus was constructed which included many neural details including: 125 olfactory nerve axonal inputs, 23 mitral/tufted cells, 90 granule cells, and 15 periglomerular cells. Individual cell EPSPs and IPSPs were calculated via non-linear summation of potentials in compartments in mitral/tufted and granule dendrites, through both axo-dendritic and dendro-dendritic simulated synaptic contacts, including realistic activation curves and synaptic delays. The rapidly approaching goal is a sophisticated frequency-to-spatial encoder.

Report:
Granger, R., Ambros-Ingerson, J., Anton, P., Whitson, J. and Lynch, G. (1989) Computational action and interaction of brain networks. In: SF Zornetzer, J Davis, C Lau, Eds. Introduction to Biological and Electronic Neural Networks. New York, Academic Press.
Granger, R, Ambros-Ingerson, J, and Lynch, G (1989) Derivation of encoding characteristics of layer II cerebral cortex. J. Cognitive Neuroscience 1:61-89.
Ambrose-Ingerson, J., Granger, R. and Lynch, G. (1990) Simulation of paleocortex performs hierarchical clustering. Science, 247, 1344-1348.

TITLE: Fourth Conference on the Neurobiology of Learning and Memory

PRINCIPAL INVESTIGATOR: James L. McGaugh
University of California, Irvine
Center for the Neurobiology of Learning and
(714) 856-5193

R&T PROJECT CODE: 4426315

CONTRACT NO:

CURRENT END DATE: 01 FEB 1991

Objective:
The conference participants will examine the locus of alterations in brain activity at three levels of organization: global cerebral function, specific systems, cellular and molecular mechanisms. The proceedings will be published.

Approach:
The contractors anticipate an international participation of 350 scientists including university faculty, postdocs, graduate students and from diverse institutions including government, private, industrial and academic laboratories. The proceedings will be published.

Progress:
This conference will take place in Irvine, California on October 17-20, 1990. The proceedings will be published by Oxford Press.

TITLE: Robust Planning and Control Using Locally Generalizing Neural Networks

PRINCIPAL INVESTIGATOR: Thomas Miller
University of New Hampshire
Dep. of Electrical & Computer Engineering
(603) 862-1326

R&T PROJECT CODE: a44e002

CONTRACT NO: N0001489J3100

CURRENT END DATE: 31 JUL 1991

Objective:
The objective of this research is to expand the theoretical understanding of neural network based learning control systems, including hierarchical learning control structures.

Approach:
The research consists of both theoretical modelling studies of system performance in learning control systems, and experimental studies using various robotic systems. Mathematical analyses will be conducted of: (a) convergence properties of control systems during continuous on-line training, (b) history dependence of neural network dynamical systems, (c) the robustness of learned planning systems for trajectory planning in incompletely trained models, and (d) utility functions such as minimum time, minimum energy, etc. for dynamical systems with constraints.

Progress:
CMAC neural nets with overlapping tapered, rather than rectangular receptive fields have been investigated. Results indicate that such nets retain the efficiency of Albus CMAC, but produce piecewise planar functions, rather than piecewise constant functions. Such nets converge faster than traditional CMAC, however performance was sensitive to placement of RF's in state space, hence a heuristic procedure was developed for placing RF's in N dimensional input space to improve performance. A protocol was developed for comparing CMAC with traditional techniques of model reference adaptive control.

Report:
Miller, W.T., Hewes, R.P., Glanz, F.H. & Kraft, L.G. (1990) Real time dynamic control of an industrial manipulator using a neural network based learning controller. To appear in: IEEE J. Robotics & Automation.

Outside Funding:
Funds for this grant are provided by DARPA.

TITLE: Computational Models of Olfactory and Spatial Cognition

PRINCIPAL INVESTIGATOR: Lynn Nadel
University of Arizona
Division of Neurobiology
(602) 621-6630

R&T PROJECT CODE: 442h025

CONTRACT NO: N0001490J1869

CURRENT END DATE: 30 JUN 1993

Objective:
A 48 element stereotrode array will be used to simultaneously record from about 150 differentiable cells in layer CA1 of the hippocampus as the rats perform a learned task involving their knowledge of spatial location. This data will be modelled and tested against a hypothesis that explains the process whereby the nervous system accomplishes this task.

Approach:
This work represents an empirical investigation of the Hebb-Marr hippocampal network theory using massively parallel recording from conscious animals. The PIs will determine whether the field potentials generated during exploration are specific to a given context (familiar vs unfamiliar) and whether these potentials change as the system stores information about new environments. The prediction of the Hebb-Marr formalism is representational stability in contrast to several connectionistic schemes based on competition which would predict representational instability.

Progress:
This grant is new in FY90.

TITLE: A Computational Analysis of Properties and Limitations of Neural Networks: Toward New Parallel Architectures

PRINCIPAL INVESTIGATOR: Tomaso A. Poggio
Massachusetts Institute of Technology
Artificial Intelligence Laboratory
(617) 253-5230

R&T PROJECT CODE: a44e001

CONTRACT NO: N0001489J3139

CURRENT END DATE: 30 SEP 1991

Objective:
The objectives of this research are (1) to establish the relations between some of the most interesting neural network architectures (eg. backpropagation nets) and classical approximation and estimation theory, (2) to leverage this understanding by proposing new architectures, and obtaining estimates of comparative performance, and (3) to demonstrate the new algorithms on real vision problems.

Approach:
The approach consists of two parts. In the first part the investigators will consider the problem of learning from the point of view of approximation theory and establish relations among the different techniques. In particular, we want to understand the approximation properties of certain specific neural nets and their precise relationship to models such as regularization, splines, radial basis functions and MRF's. In the second part, the issue of sample complexity will be examined.

Progress:
The PI has proven that: (a) neural networks derived form regularization theory (eg.radial basis functions) can approximate, arbitrarily well, continuous functions, (b) multilayer networks (eg. backpropagation) are not best approximations to continuous functions, and (c) for regularization networks, the existence and uniqueness of best approximation.

Report:
Girosi, F, and Poggio, T. (1989) Networks and best approximation property. A.I. Memo No. 1164, MIT AI Lab.
Poggio, T. (1989) A parallel vision machine that learns. In: Models of Brain Function, R.M.J. Cotterill (Ed.) Cambridge Press, 51-88.

Outside Funding:
Funds for this grant are provided by DARPA.

TITLE: Experimental and Computational Models of Neural Network Learning

PRINCIPAL INVESTIGATOR: Terrence J. Sejnowski
The Salk Institute
(619) 453-4100

R&T PROJECT CODE: 4426822

CONTRACT NO: N0001489J1766

CURRENT END DATE: 31 MAR 1991

Objective:
The P.I. has developed a combined in vitro hippocampus-entorhinal cortex slice preparation which includes both the intact hippocampal trisynaptic circuit, and input/output sites in entorhinal cortex. Studies in this preparation will focus on network interactions between cellular groups and how these are altered by the induction of long-term changes in cellular excitability. These studies will be combined with computer simulation of a neuronal network with connections faithful to hippocampal anatomy and processing units emulating important characteristics of hippocampal neurons.

Approach:
The approach of the problem of deciphering information storage and retrieval in the brain is to use the tools and techniques for simulating large parallel networks of processing units that have been developed for connectionist network models and apply them to the brain areas that are known to have roles in learning and memory. Not enough is known to completely constrain these models, so additional constraints will be sought by performing experiments on brain tissue that critically test the assumptions and predictions of the models. The goals is to co-evolve the experimental design and the models toward a better understanding of the principles that govern network learning in the brain.

Progress:
Experiments showed that commissural synapses but not mossy fiber synapses in field CA3 of the hippocampus exhibit both associative long term potentiation and long term depression.

Report:
Chattarji, S., Stanton, P., Sejnowski, T., (1989) Commissural synapses but not mossy fiber synapses in field CA3 of hippocampus exhibit both associative long term potentiation(LTP) and depression(LTD), Brain Research. 495, 145-150.

TITLE: The Organization of Memory in Humans and Non-human Primates

PRINCIPAL INVESTIGATOR: Larry R. Squire
University of California, San Diego
Psychiatry Department
(714) 452-3330

R&T PROJECT CODE: 4426023

CONTRACT NO: N0001490J1454

CURRENT END DATE: 30 NOV 1992

Objective:
Work is directed towards understanding how memory is organized in the brain. Human studies will determine what kinds of procedural knowledge are acquired when learning occurs, how long it lasts, and how such knowledge influences recall. Primate experiments are directed towards defining a structure and physiological mechanisms which serve to address, organize, or otherwise support memory.

Approach:
Two approaches will taken. The first involves cognitive testing of intact monkeys and monkeys given small neurosurgical lesions to damage or disconnect structures within the medial temporal region of the brain. The second involves studies on a population of 15 amnesic patients. Four separate experiments are proposed to address questions about 1) retrograde amnesia; 2) the nature of residual (declarative) learning ability in amnesia; 3) preserved skill learning in amnesia; and 4) preserved word priming in amnesia.

Progress:
The PI has completed a series of studies which arrive at a new conclusion about the structures and connections comprising the medial temporal lobe memory system. This work suggests that the amygdala is not part of the system damaged in human amnesia; and that the hippocampus and adjacent anatomically associated cortical structures comprise the full medial temporal lobe memory system.

Report:
Zola-Morgan, S., Squire, L.R. & Amaral, D.G. (1989) Removal of the amygdala in monkeys without damage to surrounding cortex does not impair memory nor does it exacerbate the impairment produced by lesions of the hippocampal formation. J. Neuroscience, 9, 1922-1936.
Zola-Morgan, S. Squire, L.R., Amaral, D.G. & Suzuki, W.A. Lesions of perirhinal and parahippocampal cortex that spare the amygdala and hippocampal formation produces severe memory impairment. J.Neurosci., in press

TITLE: A Biological Neural Network Analysis of Learning and Memory

PRINCIPAL INVESTIGATOR: Richard F. Thompson
University of Southern California
Psychology Department
(213) 743-2240

R&T PROJECT CODE: 4426001

CONTRACT NO: N0001488K0112

CURRENT END DATE: 31 JAN 1991

Objective:
A three year research plan includes three levels of complexity: Level I concentrates on single pathway models of conditioning involving the IO, deep nuclei, and other brain structures. These models will address phenomena at a level of detail comparable to the Rescorla-Wagner model. Level II integrates level I into real-time models of conditioning which address effects of ISI manipulations and adaptive delay of the CR. Level III incorporates the previous levels into multiple-pathway models involving more complete descriptions of the stimulus- response pathways.

Approach:
Approach involves a detailed empirical characterization of the properties of the essential neurobiological network and a quantitative computational modeling of the network that incorporates all the known properties and constraints of the actual biological network. At the behavioral level the PI has adopted the Rescorla-Wagner model; at the biological level, the neural system shown to be responsible classically conditioned nictitating membrane response will provide the experimental test bed.

Progress:
The current empirical work includes a large-scale study demonstrating that normal behavioral learning of discrete, skilled movements can be established by conjoint electrical microstimulation of the two projection pathways to the cerebellum: mossy fibers (conditioned stimulus) and climbing fibers (unconditioned stimulus). In theoretical work the PI has identified what appears to be the cerebellar circuit instantiation of the error correcting algorithm in the Rescorla-Wagner formulation of classical conditioning, termed the "delta" rule in connectionist neural network models of learning and memory.

Report:
Steinmetz, JE, Lavond, DG, and Thompson, RF (1989) Classical conditioning in pontine nucleus stimulation as a conditioned stimulus and inferior olive stimulation as an unconditioned stimulus. Synapse, 3:225-232.

TITLE: Analysis of Neural Network Issues: Scaling, Enhanced Nodal Processing, Comparison with Standard Classification Techniques

PRINCIPAL INVESTIGATOR: Gregg Wilensky
R & D Associates
(213) 822-1715

R&T PROJECT CODE: a44f004

CONTRACT NO: N0001489C0257

CURRENT END DATE: 14 DEC 1991

Objective:
The objective is to obtain, both from the literature and by original computer simulations, benchmark data comparing different types of neural networks with traditional pattern recognition procedures. An important component of this research is the analysis of the effects of scaling up the size of these nets and adding complex nodes.

Approach:
The approach will include extracting current algorithms and implementations of neural nets, and benchmark data, in order to construct a database. This will serve as a starting point for original computer simulations. Practical measures of problem complexity will be developed in order to compare the scaling and convergence properties of different neural networks. Neural nets will be compared with traditional classification techniques using identical test problems, and evaluated, based on code development time, speed of operation, learning rate, and performance of correct classifications.

Progress:
The contractor demonstrated the scaling properties of backpropagation to high dimensions in feature space for multi-dimensional Gaussian discrimination. He compared the performance of backpropagation with two conventional classifiers (nearest neighbor and Bayes) for simple image discrimination. He assessed the applicability and utility of several ANN architectures and provided continuing reports on the results.

Outside Funding:
Funds for this project are provided by DARPA.

BIOLOGICAL INTELLIGENCE

CHEMICAL MODULATORS OF INFORMATION PROCESSING

TITLE: Experimental Investigations of Synaptic Learning Rules in the Cerebral Cortex

PRINCIPAL INVESTIGATOR: Mark F. Bear
Brown University
Center for Neural Science
(401) 863-2070

R&T PROJECT CODE: 4426137

CONTRACT NO: N0001488K0756

CURRENT END DATE: 14 SEP 1991

Objective:

The effects of high-frequency electrical stimulation of the white matter on the amplitude of cortical EP's will be studied as several parameters are varied systematically. Parameters of interest will be the presence or absence of the modulatory substances acetylcholine and norepinephrine, the relative effectiveness of NMDA and non-NMDA receptors, and the effects of prior visual deprivation. The objective of these experiments is to formulate a set of rules that govern whether a burst of presynaptic activity leads to a lasting increase or decrease in synaptic strength.

Approach:

Synaptic modifications have been observed directly in the developing visual cortex of behaving kittens. Critical variables appear to be the presence or absence of extrathalamic modulatory inputs, the level of network inhibition, the amount of stimulus-driven excitatory presynaptic activity, the concurrent level of evoked post-synaptic depolarization, and the recent history of neuronal activity. In the proposed experiments, a reduced preparation of the visual cortex, the in vitro brain slice, will be used to elucidate the precise contributions of each of these variables.

Progress:

The PI demonstrated a disruption of experiencedependent synaptic modifications in the striate cortex by infusion of an NMDA receptor antagonist, and demonstrated a biochemical correlate of the critical period for synaptic modification in kitten visual cortex. He also demonstrated NMDA stimulated calcium uptake by kitten visual cortex in vitro and that visual experience regulates gene expression in the developing visual cortex.

Report:

Dudek, S.M. and Bear, M.F. (1989) A biochemical correlate of the critical period for synaptic modification in kitten visual cortex. Science 246: 673-675.

Neve, R.L. and Bear, M.F. (1989) Visual experience regulates gene expression in the developing visual cortex. Proc. Natl. Acad. Sci. USA 86:4781-4784.

TITLE: Computational Analyses of a Neural Network for Conditioned Taste Aversions.

PRINCIPAL INVESTIGATOR: Kathleen C. Chambers
University of Southern California
Department of Psychology
(213) 743-7762

R&T PROJECT CODE: 442h003

CONTRACT NO: N0001489J1296

CURRENT END DATE: 14 DEC 1991

Objective:
The objective of this research is to understand the processes of learning and memory by analyzing how the brain codes, stores and retrieves information. The PI will integrate two approaches to the study of learning and memory: an empirical neurobiological approach and a computational modeling approach. The modelling approach will incorporate all known neurobiological evidence that includes the properties and constraints of the biological system. The neurobiological studies will be impacted by the predictions about neural functioning that stem from the computational modeling.

Approach:
The research is divided into two approaches, a biological systems approach and a computational model approach. The first approach will empirically determine the neural areas that are necessary for and that modulate learning, retention, and extinction of conditioned taste avoidance (CTA). The second approach will develop computational models for the neural activity of those areas, i.e., the patterns of activity of a given known relay in the essential circuitry for CTA that change as a result of learning.

Progress:
The PI has identified four pathways necessary for a clear understanding of the neural basis of conditioned taste aversion: the US (illness) pathway, the CS (taste) pathway, the pathway for the elicited response to the CS prior to conditioning (UR-cs), and the pathway for the elicited response to the CS after conditioning. As much work has previously been done on the taste and UR-cs pathways, the PI is now concentrating on the illness and illness-taste integration pathways.

Report:
Chambers, KC (1990) A neural model for conditioned taste aversions. Ann. Rev. Neurosci., in press.
Yuan, D & Chambers, KC (1989) Temporal analysis of estradiol blockage of testosterone effect on conditioned taste aversions. APA Mtg., Alexandria, Va.

TITLE: Probing The Molecular Mechanisms of Associative Learning with Monoclonal Antibodies

PRINCIPAL INVESTIGATOR: John F. Disterhoft
Northwestern University
Department of Cell Biology & Anatomy
(312) 908-7982

R&T PROJECT CODE: 4426134

CONTRACT NO: N0001488K0399

CURRENT END DATE: 30 JUN 1991

Objective:
The technical objective is to learn more about the macromolecules that modulate the electrophysiological state and function of neurons. In collaboration with another contract (Moskal/Einstein) the PI will help produce and test a series of monoclonal antibodies which may be ideal probes that can both perturn function and identify the macromolecules normally involve in that function. The PI's testing will include both in vivo (LTP in hippocampal slices) and in vitro (behavioral classical conditioning) preparations.

Approach:
The PI will evaluate the behavioral effect of antibodies on hippocampal neurons in the behaving animal and in brain slices. Intracellular recordings will be made in hippocampal sections to biophysically evaluate the effect of each monoclonal antibody on resting activity and excitability of the cells. In awake animals, the effect of various monoclonal during acquisition of a conditioned response will be observed.

Progress:
The PI showed that learning induced after hyperpolarization reductions in hippocampus are specific for cell type and potassium conductance and that precise damage to hippocampal layer CA1 impairs classical conditioning.

Report:
Dejonge, M.C.,Black, J.P., Deyo, R.A., & Disterhoft, J.F. Learning induced after hyperpolarization reductions etc. Exper. Brain Res. (in press)
Moyer, J.R.,Deyo, R.A. and Disterhoft,J.F. Hippocampal lesions impair trace eyeblink conditioning in rabbits. Behavioral Neurosci. (in press).

TITLE: Glucose Effects on Human Memory and on Neurobiological Memory Substrates

PRINCIPAL INVESTIGATOR: Paul E. Gold
University of Virginia
Department of Psychology
(804) 924-0685

R&T PROJECT CODE: 4426140

CONTRACT NO: N0001489J1216

CURRENT END DATE: 30 NOV 1991

Objective:
The work will assess pharmacological approaches to enhance memory in humans. The proposed studies will be performed on healthy young adult volunteers and will examine dose-response curves, several memory tasks, and questions of storage vs. retrieval.

Approach:
Specifically, the PI will 1) test the possibility that glucose injections, including peripheral, central, and very localized injections, can control the establishment of long -term potentiation at both the physiologic al and structural levels, and 2) evaluate the effects of glucose on human memory.

Progress:
This project investigates glucose effects on LTP and memory in rats and humans. The PI has : (1) Investigated interactions of glucose with functions of several neurotransmitter systems, including acetylcholine, opioids, and glutamate. The findings indicate that glucose augments cholinergic functions, impairs opioid functions, and does not interact with NMDA functions. (2) Investigated the effects of glucose on LTP in the dentate gyrus, in the presence of antagonists. The findings indicate that glucose and cholinergic antagonists do not influence LTP in dentate. A novel NMDA antagonist impairs LTP and the impairment is not reversed by glucose. (3) Investigated glucose effects on human memory. Glucose actions appear to be localized to enhancement of long-term declarative memory, with no effects on short term or reference memory.

Report:
McGaugh, JL & Gold, PE 1989 Hormonal modulation of memory. In: R. Brush & S. Levine, Eds., Psychoendocrinology, New York, Academic Pr. pp.305-339.
Gold, PE 1989 Acute glucose treatment and chronic glucose regulation therapy: Potential for enhancing cognitive functions in aging. In: N. Shock et. al., Eds., The Potential for Nutritional Modulation of Aging Processes. Westport, CT, Food and Nutrition Pr.

TITLE: Three-Dimensional Organization of Circuits in the Extrapyramidal Motor System

PRINCIPAL INVESTIGATOR: Philip M. Groves
University of California, San Diego
Department of Psychiatry
(619) 534-3736

R&T PROJECT CODE: 4426637

CONTRACT NO: N0001489J1254

CURRENT END DATE: 31 OCT 1991

Objective:
The experimental work funded by this action will provide insights into the neostriatal circuitry underlying the guidance and execution of voluntary movement. These insights may be used to build a new generation of robotic devices.

Approach:
Using computer-assisted three-dimensional reconstruction, the PI will continue to analyze the 3-D organizational framework for neostriatal motor circuitry.

Progress:
In an effort to characterize the 3 dimensional configuration of basal ganglia circuitry, the PI has determined the 3-dimensional organization of cholinergic interneurons in the neostriatum in relation to location of neuropeptides, leu enkaphalin, and substance P. Computer assisted 3-dimensional reconstruction has been widely used to characterize the arrangements of basal ganglia circuitry. The PI has also studied the cellular organization of dorsal (motor) thalamus in the rat, and begun studies of hippocampal and brainstem dopaminergic innervation of nucleus accumbens which integrates limbic with motor information processing in the brain.

Report:
Martone, M, Young, SJ, Armstrong, DM & Groves, PM (1989) Ultrastructural examination of enkaphalin and substance P input to cholinergic neurons in the rat neostriatum. Soc. Neurosci. Abs., Vol. 15 (1), 473.
Sawyer, SF, Young, SJ & Groves, PM (1989) A quantitative Golgi study of anatomically identified subdivisions of motor thalamus in the rat. J. Comp. Neurol., in press.

TITLE: The Role of Lamination in Neocortical Function

PRINCIPAL INVESTIGATOR: Harvey J. Karten
University of California, San Diego
School of Medicine
(619) 534-4938

R&T PROJECT CODE: 4426131

CONTRACT NO: N0001488K0504

CURRENT END DATE: 30 JUN 1991

Objective:
A major goal of this project is to investigate the nature and benefits of lamination of cortex. In the avian brain, cortical equivalent populations ("clonal clusters") of neurons occur in non-laminated configurations, but have similar characteristics in their connections, transmitters and cell morphology. In the proposed experiments, the PI will collect detailed information about the clonal type of organization, particularly, within the avian visual system.

Approach:
(1) The anterograde and retrograde transport of several tracers will be used to explore the microcircuitry of cortical equivalent neurons in the absence of lamination. (2) The transmitters/peptides/receptors in these cortical equivalent populations will be studied using immunochemistry and in situ hybridization histochemistry. (3) The morphological characteristics of neurons in these populations will be studied using the single-cell filling technique.

Progress:
The PI is examining the cellular chemistry, connectivity, and physiology of visual forebrain regions in species where the functional equivalent of neocortex consists of clusters of neurons rather than separate layers of cortex. He has shown the patterns of connectivity between these clusters and shown that the clusters consist of biochemically distinct neuronal populations. These data are providing additional support for the hypothesis that the elaboration of mammalian, laminated cortex consisted of the intermingling of distinct cell populations.

Report:
Shimizu, T & Karten, HJ (1989) Computational equivalence with changing morphology. Cognitive Neurosci., submitted
Shimizu, T, Woodson, W, Karten, HJ (1989) Intratelencephalic connections of the ectrostriatum in birds. Soc. Neurosci., submitted

TITLE: Analysis of neural systems involved in modulation of memory storage.

PRINCIPAL INVESTIGATOR: James L. McGaugh
University of California, Irvine
Department of Psychobiology
(714) 856-5401

R&T PROJECT CODE: 4426815

CONTRACT NO: N0001490J1626

CURRENT END DATE: 31 DEC 1992

Objective:
The objective is to increase understanding of the brain systems involved in the processing of newly acquired information, and of the key brain structures and processes underlying the modulation of memory storage.

Approach:
Two different pharmacologically defined neural systems will be examined using behavioral and neurochemical techniques to more precisely define the mechanisms responsible for their distinctive memoric processes.

Progress:
The PI has obtained extensive evidence (Introini et al, 1989; Brioni et al., 1989) indicating that the retention of recently acquired information can be influenced by pharmacological treatments affecting several brain neurochemical systems, including opioid peptide, noradrenergic and GABAergic systems. Experimental data from the effects of agonists and antagonists of these systems administered peripherally as well as directly into different brain regions argue that the memory modulating effects are mediated by influences within the amygdaloid complex. The findings are consistent with the view that systems within the amygdala integrate the influences of neuromodulatory systems on memory storage.

Report:
Introini, I.B., Nagahara, A.H. & McGaugh, J.L. (1989) Memory enhancement with intra-amygdala posttraining naloxone is blocked by concurrent administration of propranolol. Brain Research, 476, 94-101.
Brioni, J.D., Nagahara, A.H.& McGaugh, J.L. (1989) Involvement of the amygdala GABAergic system in the modulation of memory storage. Brain Res, 487,105-12

TITLE: Probing the Molecular Mechanisms of Associative Learning with Monoclonal Antibodies

PRINCIPAL INVESTIGATOR: Joseph R. Moskal
Chicago Institute for Neural Surgery and Neural Research
(312) 883-8585

R&T PROJECT CODE: 4426133

CONTRACT NO: N0001488K0430

CURRENT END DATE: 30 JUN 1991

Objective:
The first objective is to generate anti-hippocampal antibodies and evaluate their effect on trace eyeblink conditioning. The second objective is to generate new monoclonal antibodies that will be useful probes to continue to study structure-function relationships between cell-surface macromolecules and synaptic plasticity.

Approach:
The PI has chosen three sources of immunogens in order to generate three new panels of antibodies. These will be; 1) freshly micropunched CA1 form adult rabbit hippocampus, 2) membranes from synaptosomes prepared from CA1 of trace-conditioned rabbits, and 3) a phosphorylated glycoprotein fraction obtained from synaptic membranes isolated from the CA1 of trace-conditioned rabbits. Upon generation of each panel of antibodies, screening will be performed in order to identify those monoclonals that are IgG's and recognize characterizable, cell-surface antigens, found on hippocampal neurons. These antibodies will then be evaluated behaviorally and neurophysiologically by a colleague (J. Disterhoft) at Northwestern under a second ONR grant.

Progress:
The PI has developed monoclonal antibodies for NMDA receptors that can enhance long term potentiation (Haring et al. 1990). Other monoclonals to hippocampal dentate gyrus changes eeg and behavioral sleep patterns (Moskal et al., 1990).

Report:
Haring, R., Stanton, P., Scheidler, M., and Moskal, J.R. (1990) Glycine like modulation of NMDA receptors by a monoclonal antibody that enhances Long Term Potentiation. J. Neurochem. (in press)
Moskal, J.R., Deyo, R., Schaffner, A., Connor, R., Panksepp, J. (1990) Intracerebral administration of a monoclonal antibody to hippocampal dentate gyrus elevates activated sleep in neonatal rats. Behav. & Neural Biol. (under review)

BIOLOGICAL INTELLIGENCE

NEURAL PROCESSING OF SENSORY INFORMATION

TITLE: Spatial Coding by Posterior Parietal Neurons

PRINCIPAL INVESTIGATOR: Richard A. Andersen
Massachusetts Institute of Technology
Department of Brain and Cognitive Sciences
(617) 253-5773

R&T PROJECT CODE: 442g004

CONTRACT NO: N0001489J1236

CURRENT END DATE: 14 DEC 1991

Objective:
The objective is to deduce the coding of coordinate transformations in parietal cortex. Questions regarding the source of the eye position signal will be addressed experimentally.

Approach:
A combination of physiological and computational techniques will be used in a series of experiments to pursue the question of how spatial transformations are accomplished in the posterior parietal cortex. The first series of experiments will determine whether head as well as eye position signals gate the visual responses of area 7a neurons, thus producing a coding for location in body-centered as well as head-centered coordinates. The second series of experiments will involve studies of 2-dimensional spatial tuning to examine the third dimension of depth by testing cells for vergence and disparity signals.

Progress:
The PI has completed two major studies as steps toward the goal of determining how populations of neurons in the posterior parietal cortex encode coordinate transformations to compute the location of visual targets in 3-D space. In neurophysiological experiments he has studied how eye position signals are integrated with retinal signals to code the location of visual targets with respect to the head. In a second study neural network models were used to examine the visual-to-motor transformation.

Report:
Andersen, R, Bracewell, M, Barash, S, Gndadt, J, Fogassi, L. (1990) Eye position effects on visual, memory and saccade-related activity in areas LIP and 7a of macaque. J. Neurosci., 10 (4): 1176-1196.
Goodman, S and Andersen, R. (1989) Microstimulation of a neural-network model for visually guided saccades. J. Cognitive Neurosci., 1: 317-326.
Andersen, R.A. (1989) Visual and eye movement functions of the posterior parietal cortex. Ann. Rev. Neurosci 12: 377-403.

TITLE: Neural Networks for Real-Time Sensory Data Processing and Sensorimotor Control

PRINCIPAL INVESTIGATOR: Randall D. Beer
Case Western Reserve University
Departments of Computer Engineering & Science
(216) 368-2816

R&T PROJECT CODE: 4426420

CONTRACT NO: N0001490J1545

CURRENT END DATE: 31 DEC 1992

Objective:
The objective of the proposed research is to elucidate the principles by which invertebrate nervous systems control locomotion behavior, and to apply this understanding to the design of more autonomous, flexible, and robust hexapod robots.

Approach:
A detailed computer model of the neural circuitry and periphery (plant) involved in the cockroach escape response will be developed. This simulation will provide an interactive medium for synthesizing results of experimental and theoretical tests of system operation. In order to demonstrate that biological control principles can be applied to robotic design, the grantees will also construct a hexapod robot, and a locomotion controller based upon a neural model under development.

Progress:
A quantitative analysis of insect leg movements has been undertaken using an NAC high speed video and computer motion analysis system. A description of the movements that occur at each joint of the leg during turns in response to wind relative to body angle has been obtained. Currently the movements of specific joints is being translated into activity in specific muscles. An original simulation system using an interactive command-line interface with graphical tools has been implemented in C and X on a DEC 3100, and a 3-D kinematic model of the insect's body has been developed for the escape response. A hexapod robot has been designed, and the locomotion controller has been ported to a PC.

TITLE: Neural Network Models for Parallel Visual Processing

PRINCIPAL INVESTIGATOR: George L. Gerstein
University of Pennsylvania
Department of Physiology
(215) 898-8752

R&T PROJECT CODE: 4426825

CONTRACT NO: N0001487K0766

CURRENT END DATE: 31 DEC 1990

Objective:
Computational rules are being defined from computer vision algorithms whose overall output replicates human psychophysical performance in preattention scene segmentation. The research proposed here is the investigation of neural net models capable of performing the same computations as the computer vision algorithms.

Approach:
To construct and simulate networks of neuronal assemblies which are capable of performing a class of visual computations that deal with texture. The network formalism is influenced and constrained by an area of mathematics describing Gabor filters and neurophysiological data derived from experiments on the mammalian visual system.

Progress:
The PI has (1) described an algorithm which uses amplitude distributions of a class of filters found to be good models for simple cells in primary visual cortex, in order to estimate the orientation of inclined textured planar surfaces relative to an observer or camera. (2) used neural network models to predict a new type of receptive field for visual neurons which would allow a human to determine its orientation relative to a textured surface, (3) tested his "gravitational" transformational tool on real data from respiratory neurons, and (4) demonstrated that dynamic behavior in observed neuronal assemblies can result from either dynamic synapses or activity in a pool of neurons.

Report:
Turner, Bajcy, & Gerstein (1989) Estimation of textured surface inclination by parallel local spectral analysis. Int. J. of Computer Vision, submitted.
Lindsey, Shannon, & Gerstein (1989) Gravitational representation of simultaneously recorded brainstem respiratory neuron spike trains. Brain Res. 483:373-378.
Gerstein, Bedenbaugh, & Aertsen (1989) Neuronal assemblies. IEEE Trans. of Biomed. Eng. 36:4-14.

TITLE: Neural Nets for DoD Communications and Sensor Signal Processing

PRINCIPAL INVESTIGATOR: Morgan Grover
Defense Group Inc.
(213) 394-8599

R&T PROJECT CODE: a44f006

CONTRACT NO: N0001489C0175

CURRENT END DATE: 30 SEP 1991

Objective:
The objectives of the research are: (1) to define and technically characterize a range of important DoD sensor and communications signal processing functions which could be enhanced by emerging neural net technologies, (2) to conduct digital simulations of specific applications, and (3) to identify potential hardware methods and additional neural net research needed for full-scale implementation.

Approach:
A comprehensive data base will be developed of priority DoD missions in pre-output signal processing which might be enhanced by neural net methods. These applications will be taken from the areas of: (1) digital communications, (2) radar sensors, (3) sonar sensors, (4) laser systems, and (5) passive optical systems. Two important applications will be selected, one in communications, and one in sensor systems. For these applications digital simulations will be conducted using multilayer neural networks appropriate for the application, including training sequences, evaluation of error rates, retraining after system perturbation, and comparison with alternative training procedures. Based upon these results probable neural network architectures will be defined in greater detail, including quantitative estimates of network size and speed, and potential approaches for hardware implementation identified.

Progress:
The PI has focused on sonar classification as a key test of neural network technology. He has analyzed the existing sonar data sets with regard to the suitability for neural net training and made substantive recommendations regarding the design of such data sets. He has analyzed the neural network efforts at a number of commercial research labs, provided reports on the status of these efforts, and made important recommendations regarding the appropriate paths for the evaluation and development of neural network technology applied to sonar signal classification.

Outside Funding:
Funds for this contract are provided by DARPA.

TITLE: Application and Validation of Neural Network Technology

PRINCIPAL INVESTIGATOR: Thomas Haley
Naval Underwater Systems Center
(401) 841-2206

R&T PROJECT CODE: 442h002

CONTRACT NO: N0001490WX24054

CURRENT END DATE: 30 SEP 1990

Objective:
The objective is to match or exceed the performance of conventional statistical classifiers applied to sonar signal using neural network techniques.

Approach:
Software implementations of neural networks will be evaluated as signal classifiers, compared with Fischer linear classifier. Enhanced algorithms for will develop to speed performance of neural nets, and extract new features from sonar data.

Progress:
Results from this program show that back propagation performed as well as conventional statistical pattern recognition techniques with the OADEX projects' best performance using a ten cue set. Restricted coulomb energy (RCE) networks performed as well with certain qualifications.

Report:
Haley, T., O'Neill, D., and Shell, R. (1989) Application and validation of neural network technology, FY89 Report, ONR Project No. N000014-89-AF-00001, Naval Underwater Systems Center, Newport, RI.

TITLE: Neural Networks for Autonomous Motor Control

PRINCIPAL INVESTIGATOR: Craig Harston
Accurate Automation Corporation
(615) 622-4642

R&T PROJECT CODE: 400e114

CONTRACT NO: N0001490C0155

CURRENT END DATE: 24 NOV 1990

Objective:
The contractor will develop neural network systems that compensate for unplanned variation, smoothly integrate multi-joint systems, and train network programs with simulated data to provide proof of these concepts.

Approach:
The contractor will design neural network systems which learn to compensate for unforseen variations of link mass, link length, direction of gravity (for undersea purposes) as well as unplanned payload inertia.

Progress:
This contract is new in FY90

TITLE: Physiology, Anatomy, and Psychophysics of Parallel Processing in the Primate Visual Cortex.

PRINCIPAL INVESTIGATOR: David H. Hubel
Harvard Medical School
Department of Neurobiology
(617) 732-1655

R&T PROJECT CODE: 442g003

CONTRACT NO: N0001488K0200

CURRENT END DATE: 30 JUN 1991

Objective:
The first objective is to examine differences in responses between cortical layers in order to learn more about the transformation of information. The second objective is a detailed analysis of single cell properties in Visual Areas 1 and 2 as predicted from psychophysical experiments. The third objective is to continue studying the intrinsic connectivity among the three kinds of stripes in Visual Area 2. The fourth objective is to use voltage sensitive dyes to examine cortical column geometry in Visual Areas 1 and 2.

Approach:
To use anatomical tracer studies, physiological recordings, 2-deoxyglucose autoradiography and voltage-sensitive dyes to more clearly define which visual functions might be processed by each anatomically defined subsystem and to use psychophysical studies to explore how human visual perception correlates with the segregation and parallel processing seen in the physiological and anatomical studies in other primates.

Progress:
PIs demonstrated that cellular response differences between the magno-and parvo-cellular divisions of the lateral geniculate are highly predictive of psychophysical results (Hubel & Livingstone, 1990). They have also begun to explore whether, as in the cat,different visual areas and different parts of single visual areas show coherent oscillations in response to global visual stimulus features.

Report:
Hubel, D. & Livingstone, M.(1990) Color and contrast sensitivity in the lateral geniculate and primary visual cortex of the macaque. J. Neurophy. (in press).
Livingstone, M. (1990) Segregation of form, color, movement, and depth processing in the visual system. in Vision and Brain, B. Cohen and I. Bodis-Wollner, eds. Raven Press, N.Y.,pp119-138.

TITLE: Neural Networks for Autonomous Motor Control

PRINCIPAL INVESTIGATOR: Michael Kuperstein
Neurogen, Inc.
(617) 232-8266

R&T PROJECT CODE: 400e113

CONTRACT NO: N0001490C0149

CURRENT END DATE: 31 OCT 1990

Objective:
The objective of the proposed Phase I study is to implement a single-jointed arm and controller for positioning unforseen payloads with accurate and stable movements.

Approach:
The proposed implementation will be based on a working computer simulation that has been shown to achieve autonomous adaptive control. The neural arm has been designed to adaptively control any number of sensory inputs with links of any number of joints. The feedforward nature of control will allow parallel implementation in real time across multiple joints.

Progress:
This contract is new in FY90.

TITLE: Biologically Based Neural Networks for Active Perceptual Processing

PRINCIPAL INVESTIGATOR: Gary Lynch
University of California, Irvine
Center for Neurobiology of Learning & Memory
(714) 856-7109

R&T PROJECT CODE: a44e007

CONTRACT NO: N0001489J3179

CURRENT END DATE: 31 JUL 1991

Objective:
The primary objective is an investigation of neural network interactions arising from a model of the olfactory bulb. These interactions will be based on "real" biological rules including dendritic structure, neurochemical events and spatio-temporal patterns of physiological synaptic changes. The objectives include a feasibility study of the electronic implementation of these biological processes in VLSI devices.

Approach:
Computer simulations at the level of single neurons and nets will be conducted to examine the information processing in distinct brain structures. This approach includes a theoretical analysis of the properties of individual networks, their hierarchical interactions, and comparison with the computational properties of existing artificial neural networks.

Progress:
The investigators have developed a new neural network based on a model of paleocortex which provides a novel and efficient method for hierarchical clustering of data. This net scales linearly in time and number of nodes. A patent application has been made.

Report:
Ambros-Ingerson, J, Granger, R, and Lynch, G (1990) Simulation of paleocortex performs hierarchical clustering. Science, 247, 1344-1348.

Outside Funds:
Funds for this grant are provided by DARPA.

TITLE: Modelling Temporal Dynamics in the Classification of Auditory Signals

PRINCIPAL INVESTIGATOR: Daniel Margoliash
The University of Chicago
Anatomy Department
(312) 702-8090

R&T PROJECT CODE: 4426501

CONTRACT NO: N0001489J1509

CURRENT END DATE: 31 JAN 1992

Objective:
The objective of this research is the elucidation of the neural mechanisms and algorithms used by animals to process auditory signals in order to provide critical insights for automating the classification of acoustic signals.

Approach:
The PI proposes to model both the recognition and production of song in oscine passerines (songbirds) and to test and modify these models in conjunction with ongoing neurophysiological and behavioral experiments. This is a well documented system for studying adaptive classification, and the PI has discovered forebrain areas with neurons which selectively respond to specific learned calls.

Progress:
This effort has two performance sites: (1) At U. Chicago, a backpropagation algorithm has been implemented and tested with complex acoustic inputs. Scaling of the net for very large problems has been undertaken. An architecture has been identified which limits the connectivity of hidden nodes while constraining the output nodes to look backwards in time. Hence the neurons output can be viewed as a sequential activation pattern of a series of output nodes that therefore preserve the temporal dynamics of neuronal responses. (2) At RAND Corp., construction of models of the response properties of neurons in HVc has been undertaken, and dynamical models are being explored which integrate temporal information in the recognition machinery rather than through conversion to a pseudo-visual recognition problem using delay lines. Neurons which show highly selective responses to particular bird calls are being modelled.

TITLE: Silicon Neural Systems

PRINCIPAL INVESTIGATOR: Carver A. Mead
California Institute of Technology
Dept. of Computer Science
(818) 356-6357

R&T PROJECT CODE: 414p006

CONTRACT NO: N0001489J1675

CURRENT END DATE: 30 SEP 1991

Objective:
The objective is to develop a deeper understanding of the collective computational capability of neural systems and to use silicon fabrication technology to implement these neural systems on silicon. These electronic neural chips and systems will be based on organizing princ-iples found in the nervous system of animals.

Approach:
The approach is to investigate the way the sensory systems process information, including the visual system, the auditory system, and sensory motor system. Analog silicon systems that learn will be investigated using electrically-erasable floating-gate memory technology. Silicon chips for visual tracking, visual focusing, binocular stereopsis, VOR, inner plexiform, neural integration, central pattern generation, and auditory classification will be designed and fabricated during this research program.

Progress:
Various neural chips have been designed and fabricated in the past year. A simple Hebbian-like silicon synapse that fires action potentials has been designed and demonstrated. The circuit is a simple model of the biological long-term potentiation (LTP) and long-term depression (LTD) effects observed in biological neurons and synapses. An all analog VLSI chip has been designed for processing auditory sound. This chip is a silicon model of pitch perception. In the area of vision, new silicon retinas have been developed with high gain photoreceptors and internal automatic gain controls. Plan is to slow down the adaptation time constant on the silicon retina chip to more closely mimic the human eye.

Report:
Mead, C. (1989). Analog VLSI and neural systems. Addison-Wesley: New York.

Outside Funding:
This project is jointly funded with ONR Electronics Division.

TITLE: Neural Networks: Comparative Performance Measurements

PRINCIPAL INVESTIGATOR: David J. Montana
BBN Laboratories incorporated
(617) 873-3000

R&T PROJECT CODE: a44d004

CONTRACT NO: N0001489C0264

CURRENT END DATE: 30 APR 1991

Objective:
The objective is the comparative performance of two types of neural networks which have been iteratively tuned, and optimized, upon sonar signal classification.

Approach:
The contractors will implement backpropagation and genetic algorithm neural networks. The comparative performance of these nets applied to sonar acoustic transient classification will be examined for cases in which components of the networks are varied. These components include (a) node transfer functions, (b) optimization criterion, and (c) training procedures. The neural networks will operate directly from spectrally transformed data. The neural networks will be iteratively tuned for classification of acoustic transients. The performance of the nets will be compared with that of traditional sonar techniques and trained human operators.

Progress:
Developed Artificial Neural Network acoustic signal classification system based on genetic algorithms and backpropagation and implemented this network on a Sun workstation with an embedded array processor. Performed initial processing of the first set of acoustic transient training data (STDS-1).

Outside Funding:
Funds for this contract are provided by DARPA.

TITLE: Seeing Pattern From Motion

PRINCIPAL INVESTIGATOR: William T. Newsome
Leland Stanford Junior University
Department of Neurobiology
(415) 725-5814

R&T PROJECT CODE: 442g001

CONTRACT NO: N0001489J1173

CURRENT END DATE: 30 NOV 1991

Objective:
Objective is to generate experimental evidence from cortical neuron activity that both tests and elaborates a computational theory of visual motion analysis.

Approach:
Approach is microelectrode recording from neurons in cortical areas MT and MST of alert monkeys viewing controlled visual patterns. The stimulus variations will be revealed in differential responses of cells tuned to component motion, pattern motion and discontinuities in moving images.

Progress:
Dr. Newsome has reestablished his laboratory at Stanford. He has obtained data from 27 MT cortical neurons, and the responses fall into 4 sub-groups (i.e., suppression, potentiation, either-or, averaging) as suggested by the theoretical work of Hildreth. Interestingly, the largest group of cells supports the "either-or" mechanism, e.g. neurons with conflicting input signals on two sides of a motion boundary respond faithfully to motion on one side , but are unaffected by motion on the other side. A "gating" or "switching" mechanism of this nature would allow accurate representation of the motion of one object, and also prevent the occurrence of "holes" in the representation of a scene. Current work examines the presence or absence of linear summation between portions of the receptive field.

Report:
Britten, K.H., Newsome, W.T., and Saunders, R.C. (1989) Effects of Inferotemporal cortex lesions on pattern-from-motion discrimination in monkeys. Soc. for Neurosci. Abstr. 15(2), 1256.

TITLE: Comparative Performance Measurements of Neural Network Nearest Matched Filters for Sonar Signal Classification

PRINCIPAL INVESTIGATOR: Patrick K. Simpson
General Dynamics Corporation
Electronics Division
(619) 573-2417

R&T PROJECT CODE: a44d003

CONTRACT NO: N0001489C0270

CURRENT END DATE: 30 SEP 1991

Objective:
The objective is to provide quantitative measures of the sonar signal classification performance of three different neural networks designed for spectro-temporal processing, and an evaluation of several alternative pre-processing techniques.

Approach:
Sonar signal classification performance will be evaluated for (a) the GDE1 fuzzy post-processed nearest matched filter neural net (an extension of Grossberg's avalanche net, and Hecht-Nielsens nearest matched filter), (b) the Viterbi net nearest matched filter (based on Gaussian classifiers and Hidden Markov Models), and (c) GDE2 on-line learning spatiotemporal pattern classifier (constructed from Kohonen's Learning Vector Quantization, and Grossberg's matched filters, temporal decay spatial activation nets, and adaptive resonance theory). Several alternative techniques for preprocessing the sonar transients into a suitable spectral estimation for the neural networks. These are: (1) fast Fourier transforms, (2) higher order zero crossings, and (3) adaptive noise cancellation by LMS or backpropagation. Performance measurements will be collected for each of the three nets, including false alarm rate. Development and operation time analysis will be performed for these applications.

Progress:
The contractors developed a GDE-1 nearest-matched-filter ANN acoustic signal classifier and trained system on first data set. Initiated development of GDE-2 on-line-learning ANN spatiotemporal pattern classifier. Also developed and evaluated several techniques for signal-to-noise enhancement.

Outside Funding:
Funds for this contract are provided by DARPA.

TITLE: Synaptic Computations for Target Ranging in Biosonar

PRINCIPAL INVESTIGATOR: Nobuo Suga
Washington University
Department of Biology
(314) 889-6805

R&T PROJECT CODE: 4426502

CONTRACT NO: N0001490J1068

CURRENT END DATE: 14 OCT 1992

Objective:
The long term objective is to arrive at description of the neural mechanism for performing cross-correlation analysis of pulse and echo for range discrimination in an echolocating bat.

Approach:
The approach will be to describe the synaptic mechanisms underlying target ranging by delay-dependent multiplication in FM-FM combination sensitive neurons of the auditory cortex. Specifically, this will be examined in terms of (1) neural delays, (2) nonlinear multiplication and (3) determinants of delay tuning. The encoding of (4) target size will also be investigated. Specific hypotheses will be tested by the microiontophoretic application of neuroactive agents onto sites in the thalamus and cortex where these mechanisms are implemented. This will provide a direct test of computational mechanisms inferred from single-unit physiology, using behaviorally relevant stimuli.

Progress:
Application of the GABA-A antagonist bicuculline was found to dramatically increase the duration of facilitation and broaden the turning of FM-FM neurons in medial geniculate and auditory cortex. Hence, inhibition plays a role in sharpening facilitative delay tuning in the auditory cortex. The facilitative response (multiplication of response) of FM-FM neurons in the MGBJ consists of two components: fast and slow. The NMDA receptor blocker APV abolishes the slow response but does not change the width of the delay-tuning curve.

Report:
Suga, N., Olsen, J.F., & Butman, J.A. (1990) Specialized subsystems for processing biologically important complex sounds: cross-correlation analysis for ranging in bat's brain. In "The Brain". Cold Spring Harbor Symp. 55 (in press).

TITLE: Detection of Acoustic Motion by Passive Listening

PRINCIPAL INVESTIGATOR: Terry T. Takahashi
University of Oregon
Department of Biology
(503) 346-4544

R&T PROJECT CODE: 4426500

CONTRACT NO: N0001489J1582

CURRENT END DATE: 31 MAY 1992

Objective:
The objective is to derive baseline data regarding the sensitivity of neurons in the owl's auditory system to moving acoustic targets in the dark, so that the capabilities of the neuronal circuits may be modelled and simulated. By studying acoustic motion-detection, the PI will address the general issue of how incoming information is stored, and how that stored information influences the perception of future signals.

Approach:
The approach utilized in this research for the design and improvement of passive, acoustic, motion-detecting and target-tracking devices is to study a biological system that is specialized for non-visual predation. The barn owl is known to capture moving prey, in absolute darkness, using only its sense of hearing. The PI has proposed a systematic, neurophysiological analysis of acoustic motion-sensitivity in the auditory system.

Progress:
The PI has discovered neurons in the midbrain of the barn owl that are sensitive to the direction of motion of a sound source. Behavioral work, required to judge performance levels of the animal in preparation for later neurophysiological analysis, is proceeding.

Report:
Takahashi, T.T. & Wagner, H. (l990) Neurons in the owls midbrain are sensitive to the direction of apparent acoustic motion. Soc.Neuro.Abs. 16, in press.

TITLE: Adaptive Information Processing in Auditory Cortex

PRINCIPAL INVESTIGATOR: Norman M. Weinberger
University of California, Irvine
Center for Neurobiology of Learning and Memory
(714) 856-5512

R&T PROJECT CODE: 4426805

CONTRACT NO: N0001490J1815

CURRENT END DATE: 30 SEP 1990

Objective:
The PI will test working hypotheses regarding putative principles of adaptive information processing in sensory cortex by obtaining neurophysiological data simultaneously from more than one neuron via an on-line objective waveform-sorting algorithm. Standard conditioning, discrimination and discrimination reversal, and contextual control of the conditioned response will all be employed in order to provide critical data concerning acquisition and storage of information. The studies proposed herein should provide foundational data on biological intelligence as expressed by adaptive information processing in neocortex.

Approach:
The frequency tuning of single neurons will be determined immediately before and after various stages of training in classical conditioning paradigms using pure tone as the conditioned stimulus and rewarding stimulation of the hypothalamus as the unconditioned stimulus. Independent behavioral indices of learning will be obtained by quantification of the pupillary dilation conditioned response.

Progress:
Conditioning, but not sensitization, produced highly specific changes in the frequency receptive fields of single neurons in non-primary areas of cat auditory cortex. Change was maximal at the frequency of the CS.

Report:
Diamond,D., Weinberger,N., (1989) The role of context in the expression of learning induced plasticity of single neurons in auditory cortex, Behavioral Neuroscience. 103: 471-494.

TITLE: Modeling of Learning Induced Receptive Field Plasticity in Auditory Neocortex

PRINCIPAL INVESTIGATOR: Norman M. Weinberger
University of California, Irvine
(714) 856-7109

R&T PROJECT CODE: a44e004

CONTRACT NO: N0001489J3178

CURRENT END DATE: 31 JUL 1991

Objective:
The objective of this research is to develop a mathematical model of adaptive information processing the brain. In particular a mathematical model of the mechanisms by which neurons in the auditory cortex are modified during learning will be developed using approaches derived from machine learning.

Approach:
The investigators will employ a gradient descent approach based on a window training procedure. This procedure has been successfully characterized in trainable machines. Data previously obtained from neurophysiological studies will be used to test and refine the model. The model will predict specific learning trajectories for different "behavioral" paradigms (eg. discrimination, extinction). The model also will predict the mechanisms of modifications of frequency response observed in neurons of the auditory cortex. The approach of combining adaptive processes from neurobiology with proven technologies based on mathematical machine learning will permit deriving principles applicable to the design and technological implementation of adaptive information processing machines.

Progress:
A multiparameter model was formulated and tested against neurophysiological tuning functions for pre-learning and learning conditions. This first model (Model 1) was less successful in accounting for the adaptive filtering during learning. A more advanced model (Model II) was developed. In model I, window functions depend on the distance of the signal frequency from the initial best frequency, and the stimulus level. In model II, learning changes the weighting at the cortical level of inputs from the frequency specific ventral medial geniculate nucleus. Model II successfully predicted the real data for both pre-learning and learning conditions, including predicting the side-band reduction in response to frequencies above and below the signal frequency.

Outside Funding:
Funds for this grant are provided by DARPA.

TITLE: Hybrid Classifier for Sonar Transient Signals

PRINCIPAL INVESTIGATOR: James W. Whiteley
Tracor Applied Sciences, Inc.
(512) 926-2800

R&T PROJECT CODE: a44d001

CONTRACT NO: N0001489C0298

CURRENT END DATE: 30 SEP 1991

Objective:
The goal of this research is to identify and evaluate artificial neural network architectures that are optimal for the adaptive classification of acoustic transients.

Approach:
The approach is to develop a hybrid classifier that integrates the best attributes of neural networks and conventional classifiers for sonar signal classification. Innovative aspects of the approach are: (1) establishment of a parametrized set of optimal features by investigation of the application of higher order spectra and image processing methods to sonar signal feature extraction; (2) the development of a time delay neural network that is matched to time varying features of transients; (3) the use of internal representations and projective fields of neural networks to identify novel discriminators; (4) the use of pre-encoded information from conventional classifiers to speed neural network training; and (5) the synergistic interaction between neural networks, feature extractors, and conventional classifiers to iteratively drive toward an optimal classifier design.

Progress:
The contractors completed preprocessing of first acoustic transient data set, including filtering and level setting for signal-to-noise enhancement and conversion to frequency-time format. Initiated development on Sun workstation with ANZA accelerator board of time-delay neural network (TDNN) for classification of preprocessed signals.

Outside Funding:
Funds for this contract are provided by DARPA.

BIOLOGICAL INTELLIGENCE

LOCAL NEURAL CIRCUIT INTERACTIONS

TITLE: Neuronal Micronets as Nodal Elements

PRINCIPAL INVESTIGATOR: Thomas H. Brown
Yale University
Department of Psychology
(203) 432-7009

R&T PROJECT CODE: a44e005

CONTRACT NO: N0001489J3141

CURRENT END DATE: 30 SEP 1991

Objective:
The objective of this research is to develop micronets based on the electrotonic structure and non-linear dynamics of real neurons, build architectures based on ensembles of these micronets, and to evaluate the computational performance of these nets on pattern recognition tasks.

Approach:
The researchers will first develop micronets which capture particular aspects of neurons. The micronets will be sparsely connected, higher-order nets. Trade-offs among number of processors, number of connections, and number of layers within the micronets will be examined. Several variants of Hebbian modification algorithms will be explored. Architectures composed of micronets will be developed. These will consist of an input buffer layer fully connected to a second layer containing micronets sparsely connected with each other by Hebbian synapses.

Progress:
Morphological and biophysical data from real neurons were incorporated into realistic simulations. The models included biophysical mechanisms for Hebbian potentiation and depression of synaptic weights. Patterned input was provided to these model neurons and the model developed feature maps of the inputs. The feature maps resulted from self-organization of functionally differentiated mosaics of feature clusters in dendritic space. Each feature cluster then responded most strongly to a particular subset of correlated inputs. The realistic simulated neuron performed this feature mapping more rapidly than an analogous artificial neural network.

Report:
Brown, TH, Mainen, Z, and Zador, A (1990) Self-organization of feature maps in dendritic trees. AIP Neural Networks for Computing Conference, Abstract.
Brown, TH, Kairiss, EW, and Keenan, CL (1990) Hebbian synapses: Biophysical mechanisms and algorithms. Ann. Rev. Neurosci. 13:475-511.

TITLE: Neural Circuitry of Behavior as a Substrate for Information Processing: A Developmental Analysis in Aplysia

PRINCIPAL INVESTIGATOR: Thomas J. Carew
Yale University
Department of Psychology
(203) 432-4675

R&T PROJECT CODE: 4426801

CONTRACT NO: N0001487K0381

CURRENT END DATE: 31 MAR 1990

Objective:
Three specific questions will be addressed, each at a behavioral and a cellular level of analysis: 1) How are neural networks for specific behavioral responses assembled and activated during development? 2) How are independent networks interconnected during development to produce integrated complex behavioral sequences? and 3) How are these integrated networks modulated by experience and learning?

Approach:
The primary goal of this research is to use development in Aplysia as an analytic tool to examine the way specific neural circuits acquire the capacity for information processing. A broad range of different defensive behaviors will be examined to permit establishing principles of neuronal organization unique to particular types of response systems on the one hand, and to principles of general significance on the other.

Progress:
In behavioral studies, the PI showed that dishabituation, sensitization and inhibition could be dissociated both by stimulus requirements (eg. dishabituation is produced by weak shock, sensitization by strong shock) and time of onset (eg. dishabituation has an early onset, sensitization a delayed onset). These findings cannot be accounted for by current models in Aplysia. The PI has also shown that 5-HT mimics the effects of tail shock in differentially modulating complex and monosynaptic input to siphon motor neurons.

Report:
Marcus, EA, Nolan, TG, Rankin, CH and Carew, TJ (1988) Behavioral dissociation of dishabituation, sensitization, and inhibition in Aplysia. Science, 241:210-213.
Fitzgerald, K & Carew, TJ (1989) Serotonin differentially modulates monosynaptic and complex EPSPs in siphon motor neurons in Aplysia. Soc. Neurosci. Abstr., 15(2), 1265.

TITLE: Synapse-Specific Facilitation During Learning and Memory

PRINCIPAL INVESTIGATOR: Gregory A. Clark
Princeton University
Department of Psychology
(609) 258-4483

R&T PROJECT CODE: 4426820

CONTRACT NO: N0001489J1954

CURRENT END DATE: 30 NOV 1990

Objective:

To determine whether long-term as well as short-term facilitation can be synapse specific, and then to define the underlying cellular mechanism (e.g. is new protein synthesis required, are new proteins used selectively?). To investigate a possible physiological and behavioral role in synapse-specific facilitation, that is, as a neural mechanism for response specificity in classical conditioning of the siphon-withdrawal response in Aplysia.

Approach:

Despite substantial progress in the neurobiology of learning, a fundamental question still remains concerning the basic unit of information storage in the central nervous system. Does learning occur at the level of individual cells, or instead at the level of individual synapses? Because synapse-specific facilitation would enhance only selected outputs of a given cell, it would provide a high degree of precision in the modification of neural pathways, and hence behavior. Synapse-specific plasticity has been incorporated into a number of conceptual and computational models of learning in neural networks. This work will directly test whether branch-synaptic facilitation occurs and will identify the relevant parameters.

Progress:

A series of experiments involving classical conditioning of Aplysia showed a significant pairing specific tendency for the direction of the response to the CS to resemble the response to the US after training, demonstrating response specificity in conditioning.

Report:

Hawkins, R., Lalevic, N., Clark, G., Kandel, E., (1989) A Classical conditioning of the Aplysia siphon withdrawal reflex exhibits response specificity, Proc. Natl. Acad. Sci. , 86, 7620-7624.

Clark, G., Hawkins, R.D., and Frost, W.N. (1990) How neural are neural networks? A comparison of information processing and storage in artificial and real neural networks. J. of Statistical Planning and Inference.

TITLE: Diverse Computational Properties of Single Neurons in Neocortex

PRINCIPAL INVESTIGATOR: Barry W. Connors
Brown University
Division of Biology and Medicine
(401) 863-2982

R&T PROJECT CODE: 4426402

CONTRACT NO: N0001490J1701

CURRENT END DATE: 14 MAR 1993

Objective:
The objective is to examine the computational properties of different types of single neocortical neurons quantitatively.

Approach:
The approach is to record from single cortical neurons in vitro, subjected to a variety of standardized protocols to determine their firing patterns in response to specified inputs, and identify the neuron morphology by dye injection. The effects of the neuromodulators norepinephrine and acetylcholine on the transform properties of different types of neurons will be examined quantitatively. In order to test the hypothesis that different intrinsic input-output properties of single neurons are significant for network behavior, a formal model of a net of realistic model neurons will be developed. This study will explore the importance of intrinsic neuronal properties in biological models of neocortex.

Progress:
This grant is new in FY90.

TITLE: Controlled Growth and Communication in Defined Patterns of Neurons

PRINCIPAL INVESTIGATOR: Thomas L. Fare
Naval Research Laboratory
Code 6090
(202) 767-4302

R&T PROJECT CODE: 4426510

CONTRACT NO:

CURRENT END DATE:

Objective:
The objectives are to (1) determine the adhesive and morphological properties of neural cells on high resolution photolithographic patterns of ultra thin films, (2) determine optimum protocols for geometric definition of synapse formation, (3) study the synaptic potentials resulting from different input configurations, and (4) relate the data to neural models.

Approach:
Explanted neurons and glial cells from mouse and rat spinal cord, hippocampus and cerebellum will be provided by NIH researchers. Alternating patterns of ultra thin films (UTF) will be prepared on glass substrates by sequential self-assembly and ablation with deep ultraviolet radiation through metallized masks. Patterns of silane-coupled ethylendiamine and tridecaflurene, and/or laminin fragments and glial cells will be used to promote neuron adhesion. The effectiveness of these materials in controlling the direction of axon and dendrite outgrowth will be determined. The functional status of synapses will be evaluated using electrical and chemical assays. Neurons will be stimulated with substrate-mounted electrodes, and responses recorded using intracellular microelectrodes. Fluorescence probes will be used to monitor spatial electrical events. The UTF process will be used to promote high impedance cellular contact with the recording electrodes.

Progress:
This grant is new in FY90.

TITLE: Neural Network Models of Primate Motor System

PRINCIPAL INVESTIGATOR: Eberhard E. Fetz
University of Washington
Department of Physiology and Biophysics
(206) 543-4839

R&T PROJECT CODE: 4426300

CONTRACT NO: N0001489J1240

CURRENT END DATE: 30 NOV 1990

Objective:
The PI will develop two types of models: on the cellular level he will model the synaptic interactions between neurons, and on the system level he will develop network simulations of the primate motor system. The objective of these models will be to provide a quantitative "real time" model of primate motor activity.

Approach:
The following experimental data will be included in a neural network model of the primate motor system: the activity of supraspinal premotor cells and their target forelimb muscles; the connections of these cells to their target motorneurons; and quantitative measures of the strength of synaptic interactions between neurons. These data were previously obtained in the laboratory of the PI.

Progress:
The PI has made progress on 3 simulation studies: (1) Modeling of the interactions between neurons in motor cortex has revealed the necessity for specific types of interneurons whose response properties resemble those of recorded cortical cells. (2) Investigation of the transmission of activity through physiologically realistic neural nets has confirmed that the effects of serial synaptic connections can be calculated by convolving cross-correlation peaks. (3) Modeling the effects of postysynaptic potentials and voltage dependent currents on firing probability has shown that PSP's can have a greater effect on postsynaptic cell firing than what is predicted by using cross-correlation peaks alone.

Report:
Matsumura, M., Chen, D.F., and Fetz, E.E. (1989) Synaptic interactions between neighboring neurons in the primate motor cortex. Soc. for Neurosci. Abstracts 15(1), 281.
Zarzecki, P., Gordon, D.C. and Fetz, E.E. (1989) Intracortical connectivity of motor cortex evaluated by spike triggered averaging and cross correlation. Soc. for Neurosci. Abstr. 15(1), 281.

TITLE: Interneuronal Information Processing

PRINCIPAL INVESTIGATOR: Daniel Gardner
Cornell University Medical College
Department of Physiology and Biophysics
(212) 746-6373

R&T PROJECT CODE: 4426021

CONTRACT NO: N0001490J1460

CURRENT END DATE: 30 NOV 1992

Objective:
Project will identify and characterize types of functional elements available to an actual neural network, the ways in which they are combined, and the functional consequences of their use. The goal is both a generalizable biophysical description of synapses and an understanding of the role of the synapses in the adaptive behavior of a cell and network.

Approach:
The PI will develop mathematical models of the stochastic processes involved in heterosynaptic plasticity. The PI will test these models experimentally with intracellular recording, under voltage clamp conditions in buccal ganglia of aplysia.

Progress:
Pre- and postsynaptic neurons specify aspects of plasticity with differing durations. Consistent with a key property of neural network models, synaptic strengths were found to differ widely between similar neurons, as well as between the same identified cells in different animals. These data promote the development of neural network models incorporating distinct sites controlling dynamic and static aspects of synaptic plasticity.

Report:
Gardner, D. (1989) Noise modulation of synaptic weights in a biological neural network. Neural Networks 2: 69-76.
Gardner, D. Paired individual and mean postsynaptic currents recorded in four-cell networks of Aplysia. J. Neurophysiology (in press)

TITLE: Synaptic Structural Effects of Long- Term Potentiation in the Hippocampal Formation

PRINCIPAL INVESTIGATOR: William T. Greenough
University of Illinois
Department of Psychology
(217) 333-4472

R&T PROJECT CODE: 4426640

CONTRACT NO: N0001489J1556

CURRENT END DATE: 31 JAN 1992

Objective:
Objective is to explore the bases of long-term potentiation (LTP) and deepen our understanding of how the neurons encode and store memories.

Approach:
The work requires the use of a number of anatomical, biochemical, and neurophysiological techniques. Many of these techniques are implemented by studying hippocampal tissue wherein chemical and anatomic qualities have been changed as a function of "experience". These changes can either be induced in vitro or in vivo, and the tissue can be removed and kept alive for long periods under appropriate conditions. The approach is to use this model system to understand mammalian learning and memory.

Progress:
Major recent findings are: (1) As reported previously with LTP, shaft and sessile spine synapses form in association with kindling in hippocampal subfield CA1 in vitro. This suggests a common mechanism for LTP and K, as well as a possible mechanism of induction of epilepsy. (2) The induction of both LTP and K is accompanied by changes in the characteristics of astrocytes. Whether astrocytic change is a primary response, and possibly instrumental in initiating the rapid synaptogenesis that we have previously reported for LTP and are currently reporting for K, or whether it is a secondary response, is currently under investigation.

Report:
Greenough, WT & Bailey, CH. (1988) The anatomy of memory: convergence of results across a diversity of tests. Trends in Neurosci. 11: 142-147.
Greenough, WT. (1989) Mechanisms of behaviorally-elicited and electrically elicited long-term potentiation. Int. J. Neurol., in press.

TITLE: Neural Mechanisms of Preparatory Processes in Stimulus-Response Associations and Movement Programming

PRINCIPAL INVESTIGATOR: Sylvan Kornblum
Regents of the University of Michigan
Department of Psychology
(313) 763-1101

R&T PROJECT CODE: 4426310

CONTRACT NO: N0001489J1557

CURRENT END DATE: 31 JAN 1992

Objective:
The objective is to provide a systematic account of the excitatory and inhibitory patterns of activity that occur in the sensory-motor transfer structures of the brain.

Approach:
Two series of experiments are planned. The first addresses the question of identifying and characterizing neural associative structures underlying the preparation of whole movements. During the behavioral stimulus-response compatibility paradigm, human cortical activity patterns will be monitored with PET scans, and monkeys cortex will be recorded electrophysiologically. The second addresses the question of neural structures involved in coding movement features in simple voluntary movement. During performance of the movement priming paradigm, single unit recordings will be obtained from motor, premotor, and parietal cortices. Sites: human work-Univ. Mich., monkey work-Canada and France)

Progress:
Two distinctive types of directionally selective. preparation-related neurons have been found. The first one may reflect a presetting mechanism which would facilitate the programming of movement direction triggered by the response signal.The second may be involved in a 'preprocessing" mechanism underlying the programming of movement direction during the preparatory period.

Report:
Hasbroucq, T. & Seal, J. (1990) A Chronometric study of the components of sensory integration & their possible neural correlates. Europ. Training Program in Brain and Behavior.
Requin, J., Riehle, A., & Seal, J. (1989) A three neuron model of cortical functioning in sensori-motor information processing. Mountcastle Symposium. Baltimore.

TITLE: Characterization of Ground Squirrel Retina Ganglion Cells

PRINCIPAL INVESTIGATOR: Nidza Lugo-Garcia
University of Puerto Rico
Medical Sciences Campus
(809) 721-4149

R&T PROJECT CODE: 4426205

CONTRACT NO: N0001489J3070

CURRENT END DATE: 30 JUN 1992

Objective:
Determine the retinal projection pathways in the central nervous system responsible for color vision. Such information may permit precise identification of the locus of visual system disorders.

Approach:
Conduct a series of experiments to (1) characterize the dendritic arborization of cells projecting to different central nervous system areas, and (2) determine if retinal ganglion cells project to more than a single target area.

Progress:
In ongoing work, Rhodamine labeled latex microspheres were stereotaxically injected into both superior colliculi of three ground sqiurrels. Survival times ranged from ten days to three months, permitting labeling of large numbers of ganglion cells, which were often completely filled with beads. Visualization of dendretic arborization was done with injections of Lucifer Yellow.

Report:
Lugo-Garcia, N., Blanco, R.E., Hughes, T.E., and Karten, H. (1990) Localization of GAD-like and GABA-like immunoreactivity in the ground squirrel retina. Anatomical Record, 4: 60A.

TITLE: Computational Capabilities of Hippocampal Neurons

PRINCIPAL INVESTIGATOR: John P. Miller
University of California, Berkeley
Department of Cell and Molecular Biology
(415) 642-9045

R&T PROJECT CODE: 4426403

CONTRACT NO: N0001490J1879

CURRENT END DATE: 30 SEP 1992

Objective:
The objective is to determine the computational capabilities of hippocampal neurons by creating realistic computer models of hippocampal neurons and their synapses.

Approach:
Realistic compartmental models of hippocampal neurons will be produced which represent neurons as a network of equivalent electrical circuits. The models will be based on functional reconstructions that combine both morphological and physiological characteristics of dendrites as well as biophysical representations of synapses. Three dimensional reconstructions of granule neurons will be produced with a computer-microscope dignitations system. This system will be extended to utilize a high resolution confocal microscope. Accurate measurements of biophysical parameters, including the synaptic currents for NMDA and non-NMDA synapses will be obtained from patch-clamp recordings. The model neurons will serve as the basis of a set of experiments on self-organization of dendritic function. This research is a collaboration of J. Miller at UC-Berkeley and Brenda Claiborne at U. Texas-San Antonio. It is complementary to research conducted by Thomas Brown at Yale, supported by a separate grant.

Progress:
This grant is new in FY90.

TITLE: Role of Spatially Distributed Ion Channels in Single Neuron Computations

PRINCIPAL INVESTIGATOR: Peter C. Schwindt
University of Washington
Department of Physiology and Biophysics
(206) 543-6310

R&T PROJECT CODE: 4426401

CONTRACT NO: N0001490J1627

CURRENT END DATE: 15 DEC 1992

Objective:
The technical objective is to gain a detailed understanding of the computational ability of a single cortical neuron.

Approach:
Single neuron computation is likely to depend in part on the properties of voltage-gated channels located on the dendritic membrane. Such channels are known to exist, and are thought to be important in neural function, but almost no information is available on their precise spatial distribution or electrical properties. The investigators propose to measure the spatial distribution and electrical properties of specific ion channels in the soma-dendritic region of cortical neurons. Based on these measurements, a mathematical, computer-based model of a cortical neuron will be constructed and analyzed to determine how the spatially distributed channels affect information transfer through the neuron.

Progress:
This grant is new in FY90.

TITLE: Experimental Data Base Generation for Computational Modelling

PRINCIPAL INVESTIGATOR: Allen I. Selverston
University of California, San Diego
Neuroscience Department
(619) 534-2672

R&T PROJECT CODE: 4426128

CONTRACT NO: N0001488K0328

CURRENT END DATE: 31 MAY 1991

Objective:
The goals of the proposed research are to obtain physiological data from an invertebrate nervous system which can be used to support the development of new computational models of neural functioning. These can serve as the basis for pattern recognition and motor control algorithms.

Approach:
A model biological circuit, the lobster gastric mill, will be experimentally studied. The model consists of only thirty neurons yet generates two complex output patterns. Moreover, these neurons are individually identifiable And their pattern of synaptic connectivity is stereotyped and well characterized. It is easy to record intracellular potentials in these neurons, including synaptic potentials. [illegible]e behavior of the entire system can be altered by injecting current into single cells or [illegible] the application of various neuromodulators which alter synaptic strengths.

Progress:
The PI has made progress in two areas: (1) The first is the role of the neuromodulator cholecystokinin (CCK) in turning on and controlling the gastric mill central pattern generator of the lobster. He has shown that CCK is present, and can be released by stimulation of an input nerve, and by natural stimuli, and CCK levels parallel changes in gastric mill activity in freely moving animals. A specific blocker for CCK has been discovered. (2) The second is the modeling of stomatogastric neural circuits. A modified Hopfield net was found to simulate 3 of the key cells of the pyloric circuit.

Report:
Turrigiano, G and Selverston, AI. (1989) Cholecystokinin-like Peptide is a modulator of a crustacean central pattern generator. J. Neurosci., 9:2486-2501.
Selverston, AI and Mazzoni, P. (1989) Flexibility of computational units in invertebrate CPG's. In: The Computing Neuron. Durbin, Miamm, & Mitchison, (Eds.) Addison-Wesley, Wokingham, England.

TITLE: Dendritic Properties and Neural Networks.

PRINCIPAL INVESTIGATOR: Gordon Shepherd
Yale University
School of Medicine
(203) 785-4336

R&T PROJECT CODE: 442h001

CONTRACT NO: N0001489J1603

CURRENT END DATE: 31 DEC 1991

Objective:
The objectives are to identify the essential features of cortical dendrites and microcircuits and to incorporate them into more realistic models of cortical function.

Approach:
Using compartmental modelling techniques, the PI will pursue analysis of logic operations inherent in intradendritic communication signals. He will develop a basic cortical circuit in parallel with experimental studies in cortical slices obtained as routine biopsies in neurosurgical operations. Since the cortex and thalamus form a functional unit, he will develop a computational model for the thalamus, and integrate this with the cortical basic circuit.

Progress:
The PI has constructed realistic models of spiny dendrites, and explored whether active properties in the spine membrane would give rise to interesting computational properties. The results showed that these dendrites are able to generate the basic logic operations of AND, OR, and NOT-AND in response to specific placements and timing of synaptic inputs. They then went on to show that these logic operations also occur if the active membrane is placed instead in the dendritic branch, but with certain differences, which include a higher threshold for synaptic activation but a larger amplitude response.

Report:
Shepherd, GM, Carnevale, NT, and Woolf, TB (1988) Comparisons between computational operations generated by active responses in dendritic branches and spines. Soc. Neurosci. Absts. 14:620.

Pougracz, E., Firestein, S., and Shepherd, G.M. (1989) Computational models of olfactory receptor neurons - comparison of conventional and whole cell data. Soc. Neurosci. Abstracts 15(2): 1142.

TITLE: Cellular Mechanisms of Long-Term Depression of Synaptic Transmission and It's Role in Memory Systems

PRINCIPAL INVESTIGATOR: Patric K. Stanton
Albert Einstein College of Medicine
Department of Neuroscience
(212) 430-2574

R&T PROJECT CODE: 400x080

CONTRACT NO:

CURRENT END DATE: 30 APR 1993

Objective:
The objective is to determine the rules and mechanisms of synaptic changes during learning. Specifically, the rules governing induction of long-term depression of synaptic strength in hippocampus, and the receptor types regulating these changes will be identified. The long term objective is to incorporate the rules for associative interactions that regulate synaptic strength into models of hippocampal function in order to generate predictions about the behavioral consequences of long-term plasticity.

Approach:
The rules and mechanisms governing synaptic plasticity will be examined in hippocampal slices. The timing rules for induction of LTD and LTP will be examined by varying the phase relation between 2 inputs. The relative duration and decay of LTD and LTP will be compared. The receptor mechanisms of LTD will be examined by applying antagonists such as AP3 and perobtaining dose-response relations. Intracellular recordings will be obtained to examine the role of postsynaptic potentials in LTD. The interaction of LTD and NMDA dependent mechanisms will be examined by varying the Mg2+ ion concentration in the medium. The link of LTD to behavioral learning will be examined by establishing the cellular mechanisms of action of agents (antagonists and monoclonal antibodies) which block delayed trace conditioning learning.

Progress:
This grant is new in FY90.

TITLE: A Study of Neuronal Properties, Synaptic Plasticity and Network Interactions

PRINCIPAL INVESTIGATOR: David Tam
Baylor College of Medicine
Division of Neuroscience
(713) 798-3100

R&T PROJECT CODE: 4426400

CONTRACT NO: N0001490J1353

CURRENT END DATE: 14 DEC 1992

Objective:
The objective is to investigate principles of synaptic interactions, in particular the relation of membrane properties of neurons to synaptic plasticity in groups of interacting neurons, as the substrates of learning and memory.

Approach:
The approach is a combined theoretical and experimental analysis of the biophysical properties of hippocampal pyramidal neurons. Realistic simulations of these neurons will permit the study of changes in signal processing when membrane properties are changed. The emergent properties exhibited by groups of interacting neurons, with specific synaptic plasticity rules, will be examined in computer reconstructions. An enhanced software system for single neuron and neuronal network simulation will be developed. Experimental data from biological (slice) preparations will be used to verify the models predictions.

Progress:
This grant is new in FY90.

TITLE: Computer Simulation of Neural Systems

PRINCIPAL INVESTIGATOR: Thomas P. Vogl
Environmental Research Institute of Michigan
(703) 520-5250

R&T PROJECT CODE: 4426132

CONTRACT NO: N0001488K0659

CURRENT END DATE: 31 JUL 1991

Objective:
The technical objectives involve finding the answers to the following questions: (1) What are the roles of presynaptic, postsynaptic, and intraneural time delays in biological network performance and stability? (2) Which features of the biologic system are essential for the memory/recognition process? (3) What are the differences between long- and short-term memory? (4) What is the role of changes in the membrane potential curves in the learning process? (5) What are the respective roles of pan-neurons vs. circum-synaptic membrane changes in learning and recall?

Approach:
Initially, efforts will focus on modelling the structure, neurochemistry, neurophysiology, and biophysics of the marine mollusc Hermissenda crassicornis with eventual extension to more complex, vertebrate systems. An essential feature of the proposed effort will be the close collaboration among neurophysiology and biophysics researchers at the National Institutes of Health (DHHS/NIH/NINCDS) and computer science and applied mathematics researchers at ERIM in all stages of the planning and execution of the research.

Progress:
The PI has developed (a) a lumped parameter model of Hermisenda which exhibits learning, retention, accelerated relearning, and output signals which have been confirmed in the biological preparation, and (b) a model based on invertebrate and vertebrate neural architectures called DYnamically STable Associative Learning (DYSTAL) which has demonstrated the abilities of signal association and classification.

Report:
Vogl, TP, Alkon, DL, Blackwell, KT (1989) Dynamically Stable Associative Learning (DYSTAL): A biologically motivated artificial neural network. Proc. IJCNN '89 Conference, V.2, 101-103.

Alkon, D.L., Vogl, T.P., Blackwell, D.T., Olds, J.L., Tam, D (1989) Pattern recognition by an artificial network derived from biologic neural systems. Biol. Cybernet.

BIOLOGICAL INTELLIGENCE

BEHAVIORAL IMMUNOLOGY

TITLE: The Influence of Stress-Induced Catecholamines on Macrophage Phagocytosis

PRINCIPAL INVESTIGATOR: Itamar B. Abrass
University of Washington
Department of Medicine
(206) 223-3089

R&T PROJECT CODE: 442d727

CONTRACT NO: N0001490J1462

CURRENT END DATE: 31 DEC 1990

Objective:

Military environments often subject personnel to acute stress with the subsequent activation of catecholamine release from sympathetic nerve terminals and the adrenal. The impact of these acute stress mediators on immune function is not known. This task will investigate the effect of physiological catecholamines on a key cell of the immune system, the macrophage. The outcome should provide information as to the effect of acute stress on resistance to microbial invasion.

Approach:

Purified rat macrophages will be cultured in vitro and exposed to a wide range of doses of epinephrine and norepinephrine in the presence or absence of pharmacologic antagonists. Macrophage phagocytic function, expression of Fc receptors and capacity to kill listeria will be examined in manipulated cells. The PI will characterize the changes in catecholamine release and responsiveness in chronically stressed animals and correlate these changes with alterations in macrophage phagocytic function.

Progress:

The PIs have demonstrated that beta-adrenergic receptors and adenylate cyclase are differentially and separately regulated during macrophage activation. Adenylate cyclase activity is rate limiting and the most phagocytically active cells are most responsive to beta -adrenergic stimulation. Preliminary studies have measured macrophage in stressed rats. Macrophages from these stressed animals, when compared with unstressed controls, demonstrated increased beta-adrenergic receptor agonist activity and increased isoproterenol responsiveness, suggesting that stress modifies catecholamine sensitivity.

Report:

Abrass, I.B. & Abrass, C.K. Regulation of Beta-Adrenergic Receptor Expression and Adenylate Cyclase Activity Following Macrophage Activation. J. Immunol. (in press).

TITLE: Investigations of Stress Induced Alterations in Neutrophil Function

PRINCIPAL INVESTIGATOR: Andrew S. Baum
Uniformed Services Univ. of The Health Sciences
F. Edward Hebert School of Medicine
(202) 295-3270

R&T PROJECT CODE: 442d008

CONTRACT NO: N0001490MP24004

CURRENT END DATE:

Objective:
This project will measure individual differences in the psychological effects elicited by a physically and emotionally demanding field training experience, and study how these effects relate to changes in endocrine and immune system activity. The goal is to better understand the mechanisms determining who gets ill under adverse conditions.

Approach:
Medical students at USUHS, all of whom must undergo a Mash-like field training exercise, will be studied before, during, and after the experience. Data to be collected include measures of degree of stress experienced and a number of endocrine and immune system activity measures. PIs are particularly interested in how endogenous opioids interact with neutrophil cells, and whether or not this interaction is affected by psychological status.

Progress:
Studies of two additional groups were initiated. Blood samples were drawn before, during, and after a Bushmaster exercise. Neutrophil random migration was increased following the exercise, stimulated migration was not, a possible hormonal mediator, dehydroepiandrosterone, was measured and showed a decrease after the exercise.

TITLE: Immunological Consequences of Social Stratification and Change.

PRINCIPAL INVESTIGATOR: Christopher L. Coe
University of Wisconsin
Department of Psychology
(608) 263-3550

R&T PROJECT CODE: 442d005

CONTRACT NO: N0001490J1543

CURRENT END DATE: 28 FEB 1991

Objective:
The primary objective is to assess how psychological and social factors affect immune competence in the individual. Data will allow determination of which immune measures are most useful for this type of research, and will explore whether or not adrenal and gonadal hormones are important in the mediation of the immune changes observed.

Approach:
Various measures of social behavior, hormonal activity, and immune function will be repeated over time. Within subject comparisons will provide information about constancy of the measures, and between subject comparisons will evaluate the effects of various social relationships and changes therein, as operationalized in housing conditions. Stressful challenge will be represented by exposure to an adult male stranger and to a female in heat, as well as by alterations in the normal light/dark cycle.

Progress:
A recently completed study on college co-eds showed that lymphocyte proliferation increased rather than decreased during periods of stress. This finding is supportive of the non-human primate model of central nervous system - immune system interaction being developed by this investigator.

Report:
Coe, C.L., Lubach, G.R., Ershler, W.B., and Klopp, R. (1989) Effect of early rearing on lymphocyte proliferation in juvenile monkeys. Brain, Behavior, and Immunity 3: 47-60.

TITLE: Behavior, Immunologic Response, and Upper Respiratory Infection

PRINCIPAL INVESTIGATOR: Sheldon Cohen
Carnegie-Mellon University
Department of Psychology
(412) 268-6684

R&T PROJECT CODE: 442d007

CONTRACT NO: N0001488K0063

CURRENT END DATE: 31 MAR 1990

Objective:
The primary purpose of the proposed research is to determine the role of natural social support systems in individual susceptibility to respiratory infection and related symptomatic behavior. The work will also investigate the role of immunologic function in linking various behavioral measures to disease, and will test two alternative models of the support--illness relationship (social support as a buffer against stress and as a main effect).

Approach:
In a prospective design approximately 1,050 healthy subjects are exposed to cold or influenza viruses (or to placebos), then quarantined for 5 days and carefully observed for illness outcomes. Subjects will be characterized on various psychosocial measures and immunologic assays before the trials begin, and these will be analyzed for their power to predict immunologic and illness outcomes.

Progress:
Initial data has been collected on 1000 subjects. Immunologic assays for baseline data and for antibody changes after challenge as well as virologic assays have been completed for approximately 600 of the volunteers.Preliminary results suggest that elevated herpes IgG is related to greater susceptibility to clinical colds.

TITLE: An Evaluation of the Effects of Stress, Nicotine, Smoking, and Smoking Abstinence on Immune System Functioning

PRINCIPAL INVESTIGATOR: Robert A. Jensen
Southern Illinois University at Carbondale
Departments of Psychology and Microbiology
(618) 536-2301

R&T PROJECT CODE: 442d009

CONTRACT NO: N0001489J1968

CURRENT END DATE: 31 MAY 1991

Objective:
Explore and characterize the effects of smoking and psychological stressors on immunocompetence.

Approach:
Perform a series of experiments (a) to determine the effects of nicotine alone and combined with stressors on the immune system functioning of laboratory rats;(b)to compare immune system functioning of smokers and non-smokers under normal and under conditions of psychological stress.

Progress:
Animal experiments are underway. Subject recruitment and selection for experiments using human volunteers is in process.

TITLE: Vulnerability to Allergic Disorders in Families of Children with Behavioral Inhibition

PRINCIPAL INVESTIGATOR: Jerome Kagan
Harvard College
Department of Psychology
(617) 495-3870

R&T PROJECT CODE: 442d006

CONTRACT NO: N0001488K0038

CURRENT END DATE: 31 MAY 1990

Objective:
The main purpose of this research is to determine if there is an association between the presence of the temperamental trait of behavioral inhibition to the unfamiliar in young children and susceptibility to allergic disorders in those children and their close relatives. A second purpose is to determine if an index of social anxiety (an adult analogue of behavioral inhibition) is associated with adult susceptibility to allergy.

Approach:
A standard medical interview designed to assess the presence of allergic and other medical disorders will be administered to the parents, grandparents, aunts and uncles of inhibited and uninhibited children. In addition, the mothers of the children will be administered separate interview schedules for the child and the child's siblings. All the adults will be given a standard social anxiety scale to test for an association between susceptibility to allergy and social anxiety.

Progress:
There have been 260 interviews conducted so far. Thirty two percent of the relatives of the fearful children report atopic allergies,e.g. hay fever, while only fourteen percent of relatives of the fearless children report these disturbances. Certain gastrointestinal disorders also appear to be of higher frequency in relatives of fearful children.

TITLE: Reciprocal Relationships Between the Immune and Central Nervous Systems

PRINCIPAL INVESTIGATOR: Keith W. Kelley
University of Illinois
Laboratory of Immunophysiology
(217) 333-5141

R&T PROJECT CODE: 442d011

CONTRACT NO: N0001489J1956

CURRENT END DATE: 31 MAY 1991

Objective:
To determine the effects of the neuroendocrine system on macrophages that secrete monokines which in turn effect the central nervous system to cause a number of adaptive behaviors associated with sickness.

Approach:
Conduct a series of experiments to determine whether selected hormones from the pituitary gland affect the synthesis of monokines secreted by activated macrophages, and whether these monokines affect the central nervous system by altering behavior that is conducive to successful elimination of infectious agents.

Progress:
Experiments are well underway in both laboratories. Preliminary data indicate that hypophysectomized rats synthesize significantly less TNF-a.

TITLE: Mood, Immunocompetence, and Illness

PRINCIPAL INVESTIGATOR: Lester Luborsky
University of Pennsylvania
Dept. of Psychiatry Research Laboratories
(215) 662-2822

R&T PROJECT CODE: 442d004

CONTRACT NO: N0001487K0498

CURRENT END DATE: 28 FEB 1990

Objective:
(1) To explore the degree of interrelationship of measures of mood, immune function and illness on a sample of cyclothymic subjects assessed longitudinally: (2) to explore factors that mediate the interrelationships among these measures, with special attention to endocrine and cognitive factors.

Approach:
The research protocol involves within-subject longitudinal recurrent measurement of mood, immunocompetence, and illness, using each subject as his or her own control. Recurrent measurement will also be made of possible endocrine and cognitive mediating factors. Multivariate analyses will identify significant interrelationships among these data.

Progress:
Approximately 1100 subjects have been screened; a total of 24 subjects fit the criteria for cyclothymia and have been evaluated one or more times on various measures ofimmunocompetence and comprise one study group. A second group composed of 28 subjects with major depression is in varying stages of evaluation of immunocompetence.

TITLE: Coping and Immune Function

PRINCIPAL INVESTIGATOR: Steven F. Maier
University of Colorado
Department of Psychology
(303) 492-6275

R&T PROJECT CODE: 442d012

CONTRACT NO: N0001490J1262

CURRENT END DATE: 30 SEP 1990

Approach:
The task employs an aggression stressor in which 'foreign' male rats are introduced as intruders into cages containing established colonies of males. This experience results in a profound psychological stress in the absence of actual physical injury. Control studies are performed with resident colonies that are not aggressive towards the intruder animal. Humoral and cellular immunity as well as stress hormone studies will be performed on aggressor and intruder animals as warranted.

Progress:
A sensitive radioimmunoassay for corticosterone has been developed; techniques to perform 6-OHDA lesions in dorsal or ventral noradrenergic systems have been established; ELISA procedures have been modified to measure IgG and IgM;a plaquing assay for KLH has been developed.

Report:
Maier, S.F. & Laudenslager, M.L., (1988) Commentary: Inescapable shock,shock controllability, and mitogen stimulated lymphocyte proliferation; Brain,Behavior,and Immunity, 2: 87-91.

MANPOWER, PERSONNEL, AND TRAINING RESEARCH AND DEVELOPMENT PROGRAM

TITLE: Using Artificial Intelligence to Aid in the Development of Causal Models

PRINCIPAL INVESTIGATOR: Clark Glymour
Carnegie-Mellon University
(412) 268-8460

R&T PROJECT CODE: 4428021

CONTRACT NO: N0001489J1964

CURRENT END DATE: 31 MAY 1990

Objective:
The objective is to deliver a practical AI tool that can be used in Navy manpower studies to identify alternative explanatory causal models for non-experimental data.

Approach:
The researchers will accomplish their technical objective through further development and testing of their pilot AI system, TETRAD II. This process will involve specific refinements of the pilot system, including addition of an automatic translation capability for use with LISREL, improvement of the user interface, improvement in the construction of initial models, addition of a capability to construct path models, and improvement in search efficiency. Monte Carlo simulations will be used to test effectiveness.

Progress:
Improved versions of the heuristic search algorithms have been developed. A study of data on attrition from Navy air traffic control training was completed, resulting in the conclusion that predictability from the available variables is low, but attrition could be reduced to 84-61% of its present value by improved trainee selection.

Report:
Spirtes, P., Sheines, R. & Glymour, C. Simulation studies of the reliability of computer aided specification using the TETRAD II, EQS, and LISREL Programs. Sociological Methods and Research, in press.

Outside Funding:
Funds for this project are provided by ONT Code 222 and the Navy Personnel Research and Development Center.

TITLE: Optimal Averaging in Performance-Test Theory

PRINCIPAL INVESTIGATOR: Marshall B. Jones
The Pennsylvania State University
(717) 531-8495

R&T PROJECT CODE: 4428023

CONTRACT NO: N0001490J1994

CURRENT END DATE: 14 APR 1991

Objective:
This work is exploring an approach for constructing and optimally scoring performance tests which maximizes stability and validity and makes effective use of testing time. The viability of the approach will be demonstrated using the Project A performance battery.

Approach:
(a) Previous results using Project A tests will be cross validated with new samples of examinees. (b) The forward projection of results from known series of trials with a view to determining when an optimum would occur if the sequence were lengthened will be empirically explored. (c) A method of analysis for determining optimal subsets of trials (i.e., those with the highest stabilities and predictive validities) will be developed. And, (d) extension of optimal selection and scoring to the multiple-criteria situation will be explored.

Progress:
This grant is new in FY90.

Outside Funding:
Funds for this project are provided by ONT Code 222.

TITLE: Understanding and Enhancing Graphics Displays for Maintenance

PRINCIPAL INVESTIGATOR: William B. Rouse
Search Technology, Inc.
(404) 441-1457

R&T PROJECT CODE: 4428018

CONTRACT NO: N0001489C0047

CURRENT END DATE: 30 NOV 1991

Objective:
To provide research results that will provide guidance on concepts and principles for the presentation of graphical information to maintainers of complex systems and to test theories on the design of graphic information-presentation for diagnostic problem-solving.

Approach:
Conduct formal experiments on: (a) the trainability of the concepts and principles underlying graphic displays at various levels of aggregation and abstraction during the maintenance of SH-3 helicopters; (b) the determination of the preferred types of display for those maintenance functions; (c) the display characteristics that influence transition among the various levels of aggregation; and (d) the influence of maintainer experience on the effectiveness of the graphic displays.

Progress:
The actions performed, strategies employed, and diagrams used during the solution of maintenance problems on the bladefold system of the SH-3 helicopter were determined. Those data were used to design CRT displays, based on aggregation and abstraction principles, that would help maintainers solve similar problems. Efficicacy of those displays was assessed with helicopter technicans solving problems using either the standard diagrammatic materials or the new display materials. The latter led to significant reductions in actions required and information sought for those tasks.

Report:
Sewell, D. R., Rouse, W. B., & Johnson, W. B. (1989). Initial evaluation of principles for graphical displays in maintenance problem-solving (Tech. Rep. ST-TR-8317-001). Norcross, GA: Search Technology, Inc.

Outside Funding:
Funds for this project are provided by ONT Code 222.

TITLE: EAM: Scientific Consultation

PRINCIPAL INVESTIGATOR: H. Wallace Sinaiko
Smithsonian Institution
(202) 357-1829

R&T PROJECT CODE: 4428032

CONTRACT NO: N0001489C0093

CURRENT END DATE: 30 APR 1991

Objective:
This contract provides support for the OCNR Manpower, Personnel and Training R&D Committee and expert consultation services for ONR's Cognitive and Neural Sciences Division. It includes continuing liaison and consultation with both domestic and international professional organizations that deal with military and civilian manpower matters.

Approach:
Research support to the programs of the OCNR Manpower R&D Committee is provided in areas such as intelligent computer-aided instruction, interactive displays and personnel testing. This support includes: organizing and making formal records of regular committee and executive group meetings; distributing relevant articles and papers from periodical literature; and participating in professional meetings and symposia. Expert consultation is provided to the basic research programs in the cognitive and neural sciences in areas such as model-based psychological measurement, sensory-guided motor control, computational vision and distributed decision making.

Report:
Sinaiko, H.W., and Elster, R. E., (1989). Manpower: The Key Ingredient, Naval Forces, No. III, Vol. X.
Sinaiko, H.W., (1990) The last American draftees, Armed Forces and Society, Vol. 16, No. 2, Winter.
Haggard, P. & Wing, A., (1990). Multi-sensory control of coordinated robotic and biological movement, Applied Psychology Unit, Medical Research Council, Applied Psychology Unit, Cambridge, U.K.

Outside Funding:
Funds for this project are provided by ONT Code 222.

TITLE: Response Latency Measures for Biographical Inventories

PRINCIPAL INVESTIGATOR: Larry J. Stricker
Educational Testing Service
(609) 734-5554

R&T PROJECT CODE: 4428019

CONTRACT NO: N0001489K0072

CURRENT END DATE: 31 DEC 1990

Objective:
This research is examining the value of using response time measures in scoring the Armed Services Adaptability Profile (ASAP), either as a substitute for or as a supplement to the regular score.

Approach:
The ASAP will be computer-administered to Navy recruits. Response time data will be collected and response time measures derived. The comparative validity of these measures vis-a-vis the regular ASAP score, as well as their incremental validity when combined with the regular score or used as a moderator or suppressor variable with the regular score, will be examined in regression analyses against the attrition criterion.

Progress:
The ASAP was administered to approximately 1,700 recruits at the Recruit Training Center, San Diego, and attrition and background data were obtained from the Defense Manpower Data Center. The statistical analysis is underway.

Outside Funding:
Funds for this project are provided by ONT Code 222.

TITLE: Database Explorer: An Adaptable and Principled Prototype

PRINCIPAL INVESTIGATOR: Jan Zytkow
George Mason University
Department of Computer Sciences
(703) 323-2713

R&T PROJECT CODE: 4428022

CONTRACT NO: N0001490J1603

CURRENT END DATE: 30 DEC 1990

Objective:
The objective of this project is to build an automated aid for database exploration that will increase the scope and efficiency of the exploration and discovery that a human analyst can do, and to test the system by applying it to several databases to be provided by NPRDC.

Approach:
A prototype of the system will be built that is based on several existing systems for scientific discovery. The consolidation will aim at a clear modular architecture for the system, a uniform internal representation of goals and results, and at automation of exploration and discovery. It will be designed so that new methods can be introduced as additional modules and so that it can be adapted to different databases by modifying the specifications of domain knowledge and goals of search. Experimental applications will test the system and yield insight into the way that a human analyst can interact with the system. Interactive modifications and improvements of the system are anticipated as a result.

Progress:
This grant is new in FY90.

Outside Funding:
Funds for this project are provided by ONT Code 222.

UNIVERSITY RESEARCH INITIATIVE: DECISION MAKING IN HIERARCHICAL TEAMS

TITLE: Effective Team Performance Under Stress and Normal Conditions

PRINCIPAL INVESTIGATOR: Daniel R. Ilgen
Michigan State University
Department of Psychology and Management
(517) 355-7503

R&T PROJECT CODE: uri5206-9001

CONTRACT NO: N0001490J1786

CURRENT END DATE: 14 MAR 1993

Objective:
The objective is to learn about modifiable factors in the selection of team members, in the design of team tasks, and in the training of team members that influence the effectiveness of team performance in decision making under conditions of uncertainty.

Approach:
Behavioral experiments will be conducted in which teams work on complex coordinated decision making tasks over extended periods of time. Time series analyses of team characteristics and performance will be done, taking into account the individual difference characteristics of team members, social factors within the group, and the cooperation and coordination requirements of the assigned tasks as variables. Stress will be manipulated by work overload and loss of normally available information.

Progress:
This grant is new in FY90.

TITLE: Contingent Coordination in Naval Team Decision Making

PRINCIPAL INVESTIGATOR: David L. Kleinman
University of Connecticut
Department of Electrical and Systems Engineering
(203) 486-3066

R&T PROJECT CODE: uri5201-9001

CONTRACT NO: N0001490J1753

CURRENT END DATE: 14 MAR 1993

Objective:
The objective is to determine how hierarchically organized teams can most effectively coordinate their communication and action in response to varying time and workload stress and the availability of communications channels.

Approach:
Normative mathematical models of theoretically optimum behavior in these situations have been developed in previous work. An appropriate simulation of the decision making task environment has also been developed. In order to determine the relationship between this theoretical analysis and actual human behavior, behavioral experiments with 3 and 4 person teams will be conducted in the simulation environment. Time stress and workload will be varied, as will the availability of communication channels and the specified organizational structure dividing responsibilities among team members.

Progress:
This grant is new in FY90.

TITLE: The Effects of Organizational Structure on Distributed Human Decision Making Under Uncertainty

PRINCIPAL INVESTIGATOR: Paul E. Lehner
George Mason University
Department of Information Systems and Engineering
(703) 323-3530

R&T PROJECT CODE: uri5202-9001

CONTRACT NO: N0001490J1680

CURRENT END DATE: 14 MAR 1993

Objective:
The objective is to identify and characterize variables that enhance coordination of tactical decision-making teams and enable teams to maintain coordinated action under the stressful conditions characteristic of tactical environments.

Approach:
PetriNet models of multi-agent decision networks will be used to derive experiments in manned systems. Outcome discrepancies are expected to suggest psychological variables that characterize team decision-making architectures.

Progress:
This grant is new in FY90.

TITLE: Hierarchical Group Decision Making: A Multidisciplinary Approach

PRINCIPAL INVESTIGATOR: Alan M. Lesgold
University of Pittsburgh
Learning Research and Development Center
(412) 624-7045

R&T PROJECT CODE: uri5205-9001

CONTRACT NO: N0001490J1664

CURRENT END DATE: 14 MAR 1993

Objective:
The objective is to determine how the process and outcome of group decision-making are affected by members' task-relevant experience as both individuals and team members and by the availability and clarity of task-relevant information.

Approach:
Experiments will be conducted in which groups work together for extended periods of time in performing a demanding simulated air-traffic control and intruder detection task, accessing information and communicating with each other via networked computer workstations. Type of hierarchical organization and personnel turnover will be experimentally varied. Detailed records of interaction will be collected and analyzed. Parallel computer simulations will both model this behavior and explore a wider range of variables and levels of each variable than is feasible in the experimental laboratory.

Progress:
This grant is new in FY90.

TITLE: Studies of Crew Coordination and Performance in Hierarchical Team Decision Making

PRINCIPAL INVESTIGATOR: Ben B. Morgan
University of Central Florida
Department of Psychology
(407) 275-2216

R&T PROJECT CODE: uri5203-9001

CONTRACT NO: N0001490J1846

CURRENT END DATE: 14 MAR 1993

Objective:
The objective of this project is to determine what types of organizational structures in hierarchical teams, and what detailed behaviors of team members serve to promote coordination and team effectiveness in such complex and demanding team tasks as tactical decision making.

Approach:
Behavioral experiments will be conducted in which hierarchically organized teams carry out synthetic team tasks designed as analogs to the requirements of real Navy jobs, as determined by task analyses. Multi-platform tactical decision-making will be among the tasks simulated. Detailed recordings of communications and other behavior will be made and analyzed. Type of hierarchical structure and workload stress will be experimentally varied.

Progress:
This grant is new in FY90.

TITLE: Information Flow and Decision Making in Teams Under Threat

PRINCIPAL INVESTIGATOR: Garold L. Stasser
Miami University
Department of Psychology
(513) 529-2415

R&T PROJECT CODE: uri5204-9001

CONTRACT NO: N0001490J1790

CURRENT END DATE: 14 MAR 1993

Objective:
The objective is to determine how types of team organization and communications affect team performance effectiveness in a tactical decision making situation, to identify communication strategies that are associated with effective performance, and to determine whether those strategies can be trained to good effect.

Approach:
Seven person teams will be engaged in an uncertain tactical decision making task comparable to the Vincennes incident. Recording and mathematical and computer simulation modeling of information transmission, dispersion and redundancy will be done. Based on a decision theoretic analysis of the task, a measure of sensitivity will be computed to index the degree to which the team's actions reflect the implications of the available information. The impact of variations in permitted communications links will be explored. Using data from both records of communications and self reports, communication strategies associated with effective performance will be identified. Experiments in which those strategies are trained will be conducted.

Progress:
This grant is new in FY90.

INDEX

CONTRACTORS

Accurate Automation Corporation, 172
Advanced Resource Development Corp., 95
Albert Einstein College of Medicine, 203
American College Testing Program, 51
Arizona State University, 125
Arizona, University of, 148

Baylor College of Medicine, 204
BBN Laboratories Incorporated, 178
Brandeis University, 83
Brown University, 94, 132, 157, 192

California Institute of Technology, 71, 85, 130, 141, 143, 177
California, University of, 68
California-Berkeley, University of, 19, 65, 84, 199
California-Davis, University of, 90
California-Irvine, University of, 70, 78, 145, 146, 163, 175, 183, 184
California-Los Angeles, University of, 104
California-San Diego, University of, 72, 120, 137, 138, 151, 161, 162, 201
Cambridge, England, 62
Carnegie-Mellon University, 4, 5, 8, 25, 37, 212, 221
Case Western Reserve University, 168
Catholic University of America, 91
Central Florida, University of, 233
Centre National De La Recherche Scientifique, 144
Chicago, University of, 29, 164, 176
Cold Springs Harbor Laboratory, 69
Colorado, University of, 217
Connecticut, University of, 122, 230
Cornell University Medical College, 195

Dartmouth College, 6
Decision Science Consortium Inc., 116
Defense Group Inc., 170

Educational Testing Service, 42, 49, 55, 56, 225
Environmental Research Institute of Michigan, 205

Florida Atlantic University, 109
Florida, University of, 93

General Dynamics Corporation, 180
George Mason University, 33, 226, 231
George Washington University, 75
Georgia Tech Research Corporation, 28

Harvard University, 9, 10, 61, 173, 214
Heinrich-Heine, 134

Illinois Institute of Technology, 26
Illinois, University of, 27, 38, 44, 46, 47, 48, 53, 77, 124, 196, 215
Illinois-Chicago, University of, 41
Institute for the Study of Learning and Expertise, 31

John Hopkins University, 11, 105

Leland Stanford Junior College, 17, 103, 179
Loyola University of Chicago, 97

Marine Biological Laboratory, 139
Massachusetts Institute of Technology, 66, 67, 73, 102, 107, 119, 149, 167
McGill University, 121
Memphis State University, 16
Miami University, 234
Michigan State University, 229

Michigan-Ann Arbor, University of, 30
Minnesota, University of, 3

National Academy of Sciences, 64, 96
Naval Health Research Center, 123
Naval Research Laboratory, 193
Naval Submarine Base, New London, 89
Naval Underwater Systems Center, 115, 171
Navy Personnel Research and Development Center, 54
Neurosciences Research Foundation, Inc., 135
Neurogen, Inc., 174
Northwestern University, 142, 159
New Hampshire, University of, 147
New York University, 81

Oregon, University of, 74, 82, 108, 182
Oregon Graduate Center, 140

Pennsylvania State University, 222
Pennsylvania, University of, 63, 169, 216
Pittsburgh, University of, 34, 36, 76, 129, 232
Portland State University, 50
Princeton University, 18, 191
Puerto Rico, University of, 198

R & D Associates, 153
Regents of the University of Michigan, 110, 197
Rochester, University of, 23, 24, 79

Salk Institute, 150
San Diego State University Foundation, 32
Science Applications International Corp., 133
Search Technology, Inc., 223
Sloan Kettering Institute, 57
Smithsonian Institution, 224
Southern California, University of, 152, 158
Southern Illinois University at Carbondale, 15, 213

Temple University, 117
Tennessee, University of, 52Texas-Austin, University of, 35
Thatcher Jones Associates, 43
Tracor Applied Sciences, Inc., 185

Umea, University of, 106
Uniformed Services University of The Health Sciences, 210
United Engineering Trustees Incorporated, 112
U.S. Army Research Institute, 118

Virginia, University of, 160

Washington University, 80, 181
Washington, University of, 7, 194, 200, 209
Wellesley College, 136
Wisconsin, University of, 92, 101, 211
Wright State University, 45

Yale University, 111, 131, 189, 190, 202

INDEX

PRINCIPAL INVESTIGATORS

Abrass, 209
Abbs, 101
Ackerman, 3
Andersen, 167
Anderson, 4

Baum, 210
Bear, 157
Beer, 168
Berger, 129
Bever, 23, 24
Bizzi, 102
Blasdel, 61
Bower, 130
Brown, 131, 189

Cabral, 115
Carew, 190
Carpenter, 25
Chambers, 158
Clark, 191
Coe, 211
Cohen, Marvin S., 116
Cohen, Sheldon S., 212
Connors, 192
Cooper, 132
Cutowsky, 103

DasGupta, 117
David son, 133
Disterhoft, 159
Drillings, 118
Duncan, 62
Durlach, 119

Eckmiller, 134
Edelman, 135
Eichenbaum, 136
Elman, 137
Evens, 26

Farah, 5
Fare, 193
Feltovich, 15
Fetz, 194
Finkel, 63
Flattau, 64
Fuster, 104

Gage, 138
Gardner, 195
Gazzaniga, 6
Gentner, 27
Georgopoulos, 105
Gerstein, 169
Gibbons, 41
Glaser, 65
Glymour, 221
Gold, 160
Govindaraj, 28
Graesser, 16
Greeno, 17
Greenough, 196
Grover, 170
Groves, 161

Haley, 171
Halvorson, 139
Hammerstrom, 140
Hammond, 29
Hanna, 89
Harston, 172
Henry, 90
Hildreth, 66, 67
Hillyard, 68, 120
Hockfield, 69
Hogan, 102
Hoffman, 70
Holland, 42
Hollerbach, 121
Hopfield, 141
Houk, 142
Howard, 91
Hubel, 173
Hunt, 7

Ilgen, 229

Jensen, 213
Johannsson, 106
John, 8
Jones, Douglas H., 43
Jones, Marshall B., 222
Jordan, 107
Junker, 44

Kagan, 214
Karten, 162
Keele, 108
Kelley,215
Kelso, 109
Kieras, 30
Kleinman, 122, 230
Kobus, 123
Koch, 71, 143
Kornblum, 110, 197
Kosslyn, 9, 10
Koubek, 45
Kramer, 77, 124
Kuperstein, 174

La Berge, 78
LaMotte, 111
Langley, 31
Laroche, 144
Lehner, 231
Lesgold, 232
Levine, 46, 47, 48
Luborsky, 216
Lufti, 92
Lugo-Garcia, 198

Lynch, 145, 175

Maier, 217
Margoliash, 176
Marshall, 32
Maunsell, 79
McGaugh, 146, 163
McKhann, 11
Mead, 177
Michalski, 33
Middlebrooks, 93
Miller, George A., 18
Miller, John P., 199
Miller, Thomas, 147
Mislevy, 49
Montana, 178
Morgan, 233
Moskal, 164

Nadel, 148
Newsome, 179

Ohlsson, 34

Paulson, 50
Pashler, 72
Pirolli, 19
Poggic, 73, 149
Porter, 35
Posner, 74

Reckase, 51
Rouse, 223
Rothblat, 75

Samejima, 52
Schneider, 76
Schofield, 36
Schulman, 80
Schwindt, 200
Sejnowski, 150
Selverston, 201
Shepherd, 202
Simmons, 94
Simpson, 180
Sinaiko, 224
Sperling, 81
Squire, 151
Stanton, 203
Stasser, 234
Steele, 95
Stevens, 82
Stout, 53
Stricker, 225
Sympson, 54
Suga, 181

Takahashi, 182
Tam, 204
Tatsouka, 55
Thompson, 152
Todd, 83
Treisman, 84

Uttal, 125

Van Essen, 85
VanLehn, 37
Vogl, 205

Wang, 56
Weinberger, 183, 184
Wilkins,38
Whitcomb, 96
Whiteley, 185
Wilensky, 153
Wong, 57

Yacyshyn, 112
Yost, 97

Zytkow, 226

INDEX

R&T PROJECT CODE

400e113, 174
400e114, 172
400o041, 95
400x038, 71
400x053, 66
400x080, 203
414p006, 177
4421536, 57
4421546, 46
4421548, 53
4421549, 52
4421550, 50
4421551, 42
4421552, 49
4421553, 41
4421554, 54
4421556, 51
4421558, 45
4421559, 55
4421560, 44
4421561, 56
4421562, 47
4421563, 101
4422438, 7
4422543, 3
4422547, 15
4422548, 16
4422549, 17
4422550, 19
4422551, 9
4422553, 5
4422554, 26
4422556, 8
4422557, 6
4422558, 11
4422559, 4
4422560, 10
4424167, 118
4424202, 94
4424207, 89
4424208, 78
4424210, 75
4424212, 72
4424213, 91
4424216, 102
4424218, 111
4424219, 70
4424220, 69
4424221, 81
4424223, 109
4424224, 105
4424226, 92
4424227, 93
4424228, 77
4424229, 80
4424232, 120
4424233, 74
4424238, 117
4424239, 121
4424240, 62
4424241, 83
4424242, 79
4424243, 65
4424244, 67
4424245, 82
4424246, 110
4424247, 97
4424248, 112
4424249, 119
4424250, 106
4424251, 84
4424253, 107
4424254, 90
4424255, 63
4424256, 123
4424257, 103
4424901, 76
4425083, 85
4425800, 104
4426001, 152
4426016, 138
4426021, 195
4426023, 151
4426124, 96
4426125, 64
4426126, 142
4426128, 201
4426129, 135
4426131, 162
4426132, 205
4426133, 164
4426134, 159
4426136, 130
4426137, 157
4426140, 160
4426200, 131
4426201, 143
4426205, 198
4426300, 194
4426310, 197
4426315, 146
4426330, 144
4426400, 204
4426401, 200
4426402, 192
4426403, 199
4426404, 137
4426420, 168
4426421, 136
4426500, 182
4426501, 176
4426502, 181
4426510, 193
4426556, 68
4426637, 161
4426640, 196
4426801, 190

4426802, 108
4426803, 141
4426805, 183
4426815, 163
4426817, 129
4426820, 191
4426822, 150
4426825, 169
4426830, 132
4428004, 28
4428007, 43
4428016, 24
4428017, 25
4428018, 223
4428019, 225
4428020, 48
4428021, 221
4428022, 226
4428023, 222
4428032, 224
4429010, 122
4429011, 125
4429012, 116
4429013, 115
4429015, 124
433g008, 38
433g016, 31
433g022, 35
442c010, 32
442c013, 36
442c026, 18
442d004, 216
442d005, 211
442d006, 214
442d007, 212
442d008, 210
442d009, 213
442d011, 215
442d012, 217
442d727, 209
442f001, 37
442f002, 30
442f003, 29
442f005, 23
442f006, 33
442f007, 27
442f008, 34
442g001, 179
442g002, 73
442g003, 173
442g004, 167
442g005, 61
442h001, 202
442h002, 171
442h003, 158
442h004, 139
442h010, 145
442h011, 134
442h020, 140
442h025, 148
a44d001, 185
a44d003, 180
a44d004, 178
a44e001, 149
a44e002, 147
a44e004, 184
a44e005, 189
a44e007, 175
a44f003, 133
a44f004, 153
a44f006, 170
uri5201-9001, 230
uri5202-9001, 231
uri5203-9001, 233
uri5204-9001, 234
uri5205-9001, 232
uri5206-9001, 229